North of 60

Environmental Studies No. 9

# Interactions Between Wildlife, Trapper-Hunters and Seismic Lines in the Mackenzie Valley Region, N.W.T., Canada
## Part I
## Aubry-Colville Lakes

Environmental Studies No. 9

# Interactions Between Wildlife, Trapper-Hunters and Seismic Lines in the Mackenzie Valley Region, N.W.T., Canada.
## Part I
## Aubry-Colville Lakes

R.R. Riewe
R and R Research Limited
Winnipeg, Manitoba

© Published under authority of the
Hon. J. Hugh Faulkner, Minister
of Indian and Northern Affairs Canada,
Ottawa, 1979.
QS-8203-000-EE-A1
Catalogue No. R71-19/9-1979
ISBN 0-662-10429-3

This report was prepared under contract for the Arctic Land Use Research Program, Northern Environmental Protection and Renewable Resources Branch, Department of Indian Affairs and Northern Development.

The views, conclusions and recommendations expressed herein are those of the author and not necessarily those of the Department.

Cette publication peut aussi être obtenue en français.

## TABLE OF CONTENTS

Page

1. Summary . . . . . . . . . . . . . . . . . . . . . . . . . . . 1

2. Introduction . . . . . . . . . . . . . . . . . . . . . . . . 3

    2.1 Objective . . . . . . . . . . . . . . . . . . . . . . . 3
    2.2 Study Area . . . . . . . . . . . . . . . . . . . . . . . 3

        2.2.1 Study Sites and Field Operations . . . . . . . . . . 3
        2.2.2 Physiography of the Study Area . . . . . . . . . . 8
        2.2.3 Climate of the Study Area . . . . . . . . . . . . . 8
        2.2.4 Habitats in the Study Area . . . . . . . . . . . . 8
        2.2.5 Wildlife in the Study Area . . . . . . . . . . . . 9

3. Methods . . . . . . . . . . . . . . . . . . . . . . . . . . . 10

    3.1 Floral and Disturbance Studies . . . . . . . . . . . . . 10

        3.1.1 Botanical Collections . . . . . . . . . . . . . . . 10
        3.1.2 Vegetative Analysis Techniques . . . . . . . . . . 10
        3.1.3 Subsidence Measurements . . . . . . . . . . . . . . 12

    3.2 Wildlife Studies . . . . . . . . . . . . . . . . . . . . 12

        3.2.1 Small Mammal Trapping Techniques . . . . . . . . . 12

            3.2.1.1 Summer 1976 . . . . . . . . . . . . . . . . . 12
            3.2.1.2 Summer 1977 . . . . . . . . . . . . . . . . . 14

        3.2.2 Vole Food Preference Tests . . . . . . . . . . . . 17
        3.2.3 Wildlife Track Survey . . . . . . . . . . . . . . . 18

    3.3 Snow Measurements . . . . . . . . . . . . . . . . . . . 18

4. Results and Discussion . . . . . . . . . . . . . . . . . . . 19

    4.1 Description of Major Habitats . . . . . . . . . . . . . 19

        4.1.1 Open Spruce-Lichen Forest . . . . . . . . . . . . . 19
        4.1.2 Lake Shoreline . . . . . . . . . . . . . . . . . . 21
        4.1.3 Pond and River Margins . . . . . . . . . . . . . . 23
        4.1.4 Fens and Bogs . . . . . . . . . . . . . . . . . . . 23
        4.1.5 Lichen Heath . . . . . . . . . . . . . . . . . . . 26
        4.1.6 Crowberry Heath . . . . . . . . . . . . . . . . . . 26
        4.1.7 Natural Subsidence . . . . . . . . . . . . . . . . 28

Page

4.1 Description of Major Habitats (continued) . . . . . . . . .

4.1.8 Disturbed Sites . . . . . . . . . . . . . . . . . . 28

4.1.8.1 Oil Drilling Site . . . . . . . . . . . . . 28
4.1.8.2 Track Vehicle Trails . . . . . . . . . . . 30
4.1.8.3 Native Camps . . . . . . . . . . . . . . . 30
4.1.8.4 Seismic Lines . . . . . . . . . . . . . . . 30

4.2 Description of Habitats on the Mark-Recapture Plot . . . . 35

4.3 Results of Vegetation Studies . . . . . . . . . . . . . 37

4.3.1 Effects of Seismic Activity on Vegetation . . . . 37
4.3.2 Species Richness On and Off Seismic Lines . . . . 39
4.3.3 Thermokarst and Erosional Subsidence along Seismic Lines . . . . . . . . . . . . . . . 42

4.4 Results of Small Mammal Studies . . . . . . . . . . . . . 42

4.4.1 Small Mammal Populations . . . . . . . . . . . . . 42
4.4.2 Vole Food Preference Tests . . . . . . . . . . . . 45
4.4.3 Vole Home Ranges . . . . . . . . . . . . . . . . . 55
4.4.4 Effects of Cut Lines on Small Mammals . . . . . . 63
4.4.5 Habitat Utilization by Red-Backed Voles on the Mark-Recapture Plot . . . . . . . . . . . . 65

4.5 Snow Conditions during April and May 1977 . . . . . . . . 65

4.6 Results of Winter Track Survey and Reactions of Wildlife to Seismic Lines . . . . . . . . . . . 72

4.6.1 Willow Ptarmigan . . . . . . . . . . . . . . . . . 72
4.6.2 Voles and Lemmings . . . . . . . . . . . . . . . . 76
4.6.3 Red Squirrel . . . . . . . . . . . . . . . . . . . 76
4.6.4 Snowshoe Hare . . . . . . . . . . . . . . . . . . 79
4.6.5 Moose . . . . . . . . . . . . . . . . . . . . . . 79
4.6.6 Caribou . . . . . . . . . . . . . . . . . . . . . 79
4.6.7 Short-Tailed Weasel . . . . . . . . . . . . . . . 87
4.6.8 Mink . . . . . . . . . . . . . . . . . . . . . . . 87
4.6.9 Marten . . . . . . . . . . . . . . . . . . . . . . 87
4.6.10 Wolverine . . . . . . . . . . . . . . . . . . . . 88
4.6.11 Arctic and Red Foxes . . . . . . . . . . . . . . 88
4.6.12 Wolf . . . . . . . . . . . . . . . . . . . . . . . 88
4.6.13 Other Fur-Bearers . . . . . . . . . . . . . . . . 89

4.7 Usefulness of Seismic Lines to Trappers and Hunters . . . 89

5. Literature Cited . . . . . . . . . . . . . . . . . . . . . 92

Page

6. Appendices . . . . . . . . . . . . . . . . . . . . . . . . . 99

6.1 Vascular Plants Recorded in the Vicinity of Aubry Lake, N.W.T. . . . . . . . . . . . . . . . . . . . 99
6.2 Lichens Collected in the Vicinity of Aubry Lake, N.W.T. . 99
6.3 List of Bryophytes Collected at Aubry Lake, N.W.T. . . . . 110
6.4 Botanical Description of Traplines . . . . . . . . . . . . 111

7. Acknowledgements . . . . . . . . . . . . . . . . . . . . . . 114

8. Postscript . . . . . . . . . . . . . . . . . . . . . . . . . 114

## LIST OF FIGURES

Page

1. Colville Lake village on the southeast shore of Colville Lake, 58 km north of the Arctic Circle . . . . . . 4

2. Map of the Aubry-Colville Lakes study area . . . . . . . . . . . 5

3. Map showing the study sites at the north end of Aubry Lake . . 6

4. Map showing the study sites at the south end of Aubry Lake . . 7

5. A plumb reading being taken along a traverse line which crosses a 1969-cut seismic line . . . . . . . . . . . . 13

6. A brown lemming captured in a Museum Special trap . . . . . . 15

7. Small mammal mark-recapture study plot located near the north end of Aubry Lake at 67°36'N, 126°30'W . . . . 16

8. Open spruce-lichen forest at the north end of Aubry Lake . . . 20

9. Sand-and-cobble beach at the north end of Aubry Lake . . . . . 22

10. Pond margin surrounding a small shallow thermokarst pond near the north end of Aubry Lake . . . . . . . . . . . . . . . . 24

11. Fen with open spruce-lichen forest in the background . . . . . 25

12. Small lichen heath on the edge of Aubry Lake . . . . . . . . . 27

13. Crowberry heath on an exposed esker at the north end of Aubry Lake . . . . . . . . . . . . . . . . 27

14. A natural thermokarst landslip along the north shore of Aubry Lake . . . . . . . . . . . . . . 29

15. Aerial view looking southeast along bulldozer supply trails leading to Mobile-Colville E-15 drilling site at the south end of Aubry Lake . . . . . . . . . . . . . . . . . 31

16. Native fishing camp at the south end of Aubry Lake . . . . . . 31

17. Looking east along seismic line 11 at the south end of Aubry Lake . . . . . . . . . . . . . . . . . 32

18. Thermokarst pool on a seismic line cut in 1969 near the south end of Aubry Lake . . . . . . . . . . . . . . . . 33

Page

19. Seismic line cut in 1969 on the south slope of Colville Ridge . . . . . . . . . . . . . . . . . . . . . . . 34

20. Seismic line at the north end of Aubry Lake cut in March 1975 . . . . . . . . . . . . . . . . . . . . . . . 36

21. Density of trees and shrubs on various-age seismic lines and in adjacent open spruce-lichen forest . . . . . . . . . . . 38

22. Comparison of percent cover of various strata of vegetation in the open spruce-lichen forest and on seismic lines at the north and south ends of Aubry Lake . . . . . . . . . . 41

23. Average number of plant species per quadrat in various habitats and on seismic lines . . . . . . . . . . . . 43

24. Thermokarst subsidence measurements taken along four traverse lines crossing supply trails leading to the Mobile-Colville E-15 drill site . . . . . . . . . 44

25. The largest home range of an adult male red-backed vole on the Aubry Lake plot between 15 July and 5 August 1976 . . . 58

26. The largest home range of a juvenile red-backed vole on the Aubry Lake plot between 15 July and 5 August 1976 . . . 59

27. Home ranges of the 11 adult male red-backed voles captured at three or more trap stations between 15 July and 5 August 1976 on the Aubry Lake plot . . . 60

28. Home ranges of the ten adult female red-backed voles captured at three or more trap stations between 15 July and 5 August 1976 on the Aubry Lake plot . . . 61

29. Aubry Lake mark-recapture plot showing the total number of small mammal captures at each trap station . . . . . . . . . 64

30. Hardness measurements being taken at a snow station along a seismic line . . . . . . . . . . . . . . . . . . . . . 68

31. Snow accumulation in the spruce-lichen forest in the Aubry-Colville area varied from 60 to 120 cm in April 1977 . . . . . . . . . . . . . . . . . . . . . . 69

32. Heavy qali (snow which accumulates in trees) loads on white spruce . . . . . . . . . . . . . . . . . . . . . . 71

33. Reactions of wildlife to seismic lines in the Aubry-Colville Lakes region during April and May 1977 . 74

Page

34. Sign of ptarmigan feeding on exposed willow buds . . . . . . . 77

35. Openings of ventilation shafts in a small sedge swale . . . . 78

36. Red squirrel tracks crossing a seismic line at right angles . 80

37. Members of the Bluenose caribou herd loafing along the east shore of Aubry Lake in April 1977 . . . . . . . 81

38. Caribou feeding sign along the shoreline of Aubry Lake, April 1977 . . . . . . . . . . . . . . . . . . . . . . . . 83

39. A trail made by 400 caribou which were observed moving up the north arm of Aubry Lake on 20 April 1977 . . . . 84

40. Sign of 40 caribou on an east-west seismic line which they followed for at least 16 km and perhaps for more than 32 km . . . . . . . . . . . . . . . . . . 86

41. A seismic line cutting through hilly, forested topography at the south end of Aubry Lake, April 1977 . . . . . . . . . . 90

# LIST OF TABLES

Page

1. Importance values of the tree and shrub strata on seismic lines and adjacent open spruce-lichen forest . . . . 40
2. Results of exploratory traplines set at the north end of Aubry Lake in 1976 . . . . . . . . . . . 46
3. Summary of small mammal kill trapping on and off seismic lines at Aubry Lake in summer 1976 . . . . . 47
4. Summary of small mammal kill trapping on and off seismic lines at Aubry Lake in summer 1977 . . . . . 48
5. Vole food preferences as determined by cafeteria feeding trials . . . . . . . . . . . . . . . . . . . . 49
6. Minimum area home ranges of red-backed voles on the Aubry Lake plot, 15 July to 5 August 1976 . . . . . . . 57
7. Snow station data collected in the Aubry-Colville Lakes area, 10 April to 1 May 1977 . . . 66
8. Mean values for snow data collected at snow stations on seismic lines and at bush sites in the Aubry-Colville Lakes area, 10 to 15 April 1977 . . . . . 70
9. Mean snow depths at varying distances from the shoreline of Aubry Lake, 1 May 1977 . . . . . . . . . . 73

## 1. SUMMARY

The objective of this study was to determine if and how the distribution and movement of game and fur-bearing animals are affected by seismic lines. As a corollary, the study was to ascertain to what extent seismic lines are used by trapper-hunters in preference to traditional routes. In order to obtain this information, it was necessary to first examine the effects of seismic lines upon the vegetation and small mammals which support the game and fur.

This study was conducted in the vicinity of Aubry and Colville Lakes, N.W.T. (study area encompassed 4,477 km$^2$) during three periods: 27 May to 31 August 1976, 7 April to 10 May 1977 and 1 to 24 August 1977. The open spruce-lichen forest is the dominant habitat in the region. Less extensive terrestrial habitats include lake shorelines, river and pond margins, bogs and fens, lichen heaths, crowberry heaths and thermokarst landslips. These natural habitats have been altered by seismic lines cut between 1969 and 1975, by several bulldozer supply trails, by an abandoned drilling site and by several temporary and permanent native campsites.

Seismic lines of various ages displayed different patterns of thermokarst subsidence and vegetation. Lines cut in 1969 have slumped an average of 34.2 cm below the adjacent undisturbed surface. Herbs, half-shrubs and grassy plants dominate these older lines. Seismic lines cut in 1975 showed far less evidence of thermokarst action; this is probably due to the use of protective "mushroom shoes" on the bulldozer blades. These newer lines are covered primarily with detritus, trees, shrubs, herbs and half-shrubs, while grassy plants are comparatively unimportant.

The red-backed vole is the most common small mammal in the area; in 24,192 trap-nights (using kill and live traps) 809 red-backed voles were captured, whereas only 45 meadow voles, 39 chestnut-cheeked voles, 22 masked shrews and 17 brown lemmings were taken.

From cafeteria feeding tests it was determined that red-backed voles possess a marked preference for fruits and flowers and that they reject stems, leaves and roots. Most of the preferred plants thrive along the margins of rivers and ponds, along shorelines or in moist disturbed areas such as seismic lines. The red-backed voles, however, tend to avoid these wet habitats and more frequently utilize the spruce-lichen forests. There were only 1/4 as many red-backed voles captured on seismic lines as were taken in the adjacent bush. Even though the voles generally avoid seismic lines, they will cross them to get from one part of their home range to another. Red-backed voles displaced by seismic lines are occasionally replaced by meadow voles along the older lines where moist grassy habitats develop in thermokarst slumps. During this study, however, the meadow voles never surpassed the number of red-backed voles displaced. Thus, it appears that seismic lines add habitat diversity to the predominant spruce-lichen forest but they are, nonetheless, detrimental to the production of voles. The density of seismic lines in the study area is

such that the decline in vole biomass is probably less than 0.05%.

During the spring field study, wildlife reacted to the seismic lines in varying ways. Willow ptarmigan appeared to be indifferent to the seismic lines unless there were exposed willows on the lines; in such cases the birds did not hesitate to feed on the lines. Ptarmigan reacted to other exposed areas, such as along rivers and lakes, in the same manner. Voles, red squirrels and snowshoe hares tended to avoid the seismic lines. Wolves, red foxes and arctic foxes occasionally utilized the seismic lines as travel routes. Mink never used the seismic lines, marten rarely followed them but weasels occasionally hunted along the lines. There was no sign of beaver, otter or muskrat utilizing the lines, and there was insufficient sign of wolverine to determine their reaction to the lines. Moose did not make use of the lines. Caribou, on the other hand, exhibited a moderate tendency to utilize the seismic lines as travel routes when snow conditions and orientation of the lines were relatively suitable to the direction of their migration. Whether this behaviour would have any significant effect in diverting migrations from normal routes is not known. My observations indicate, however, that lakes and water systems are more important to caribou as travel routes than are seismic lines.

From discussions with the Colville Lake trapper-hunters and from observations of their bush trails, it is clear that they are aware of the relatively lower productivity of fur and game on the seismic lines and that they do not bother to trap along these lines. Even if the productivity was as high on the seismic lines as in the surrounding countryside, there is another reason for the people to avoid these lines. Seismic lines slash through the land in an indiscriminant fashion, and, where the lines cut through hilly country, it is far more difficult to traverse the steep inclines on the seismic lines than it is to follow the natural topographic corridors such as lakes, ponds, rivers and their valleys or even the contour lines through the bush. This is especially true for the Colville people who use maneuverable dog teams rather than snowmobiles in the bush.

As of 1977 seismic lines covered approximately 632 ha or 0.18% of the land surface in the study area. I have seen no evidence that seismic lines in the area benefit the wildlife or the trapper-hunters of Colville Lake. On the other hand, I find it difficult to believe that the seismic lines, which represent such a small percentage of the land surface, have reduced the carrying capacity of the region for the fur-bearers or game animals. It is difficult, however, to predict what the accumulative effect would be upon the carrying capacity of the area (particularly for caribou) if additional seismic operations were conducted in the region.

# 2. INTRODUCTION

## 2.1 Objective

The objective of this study was to determine the effects of seismic lines upon the distribution and movements of fur-bearing mammals and terrestrial game species which in turn may affect the success of trapper-hunters operating in the vicinity of seismic lines. In order to obtain this information, it was necessary to first examine the effects of seismic lines upon the flora and small mammals which support the fur and game species.

## 2.2 Study Area

### 2.2.1 Study Sites and Field Operations

The Aubry-Colville Lakes area was chosen as the study site because:

(1) It is within the range of the Colville Lake Indians (Fig. 1) who are still actively engaged in trapping, particularly for marten (*Martes americana*) (Savishinsky, 1974).

(2) These lakes are surrounded by numerous seismic lines of differing ages and successional stages.

(3) The large bodies of water provide easy access to the seismic lines.

(4) Botanical and small mammal studies have never been conducted in this isolated area, and thus the data gathered provide additional scientific knowledge on this region.

The study area (Fig. 2) encompasses 4,477 km$^2$ of which about 25% is covered with water bodies while seismic lines cover approximately 632 ha or 0.18% of the land area.

Field studies were conducted during three periods: 27 May to 31 August 1976, 7 April to 10 May 1977 and 1 to 24 August 1977. During the first summer the field crew spent 308 person-days on Aubry Lake examining the flora and the small mammals in the vicinity of seismic lines (Figs. 3 and 4). The following spring 136 person-days were spent in the field examining the reactions of terrestrial game and fur-bearers to seismic lines by means of track surveys. An additional 65 person-days were spent during the second summer in continuing the small mammal studies.

Fig. 1. Colville Lake village (67°10'N, 126°0'W) on the southeast shore of Colville Lake, 58 km north of the Arctic Circle.

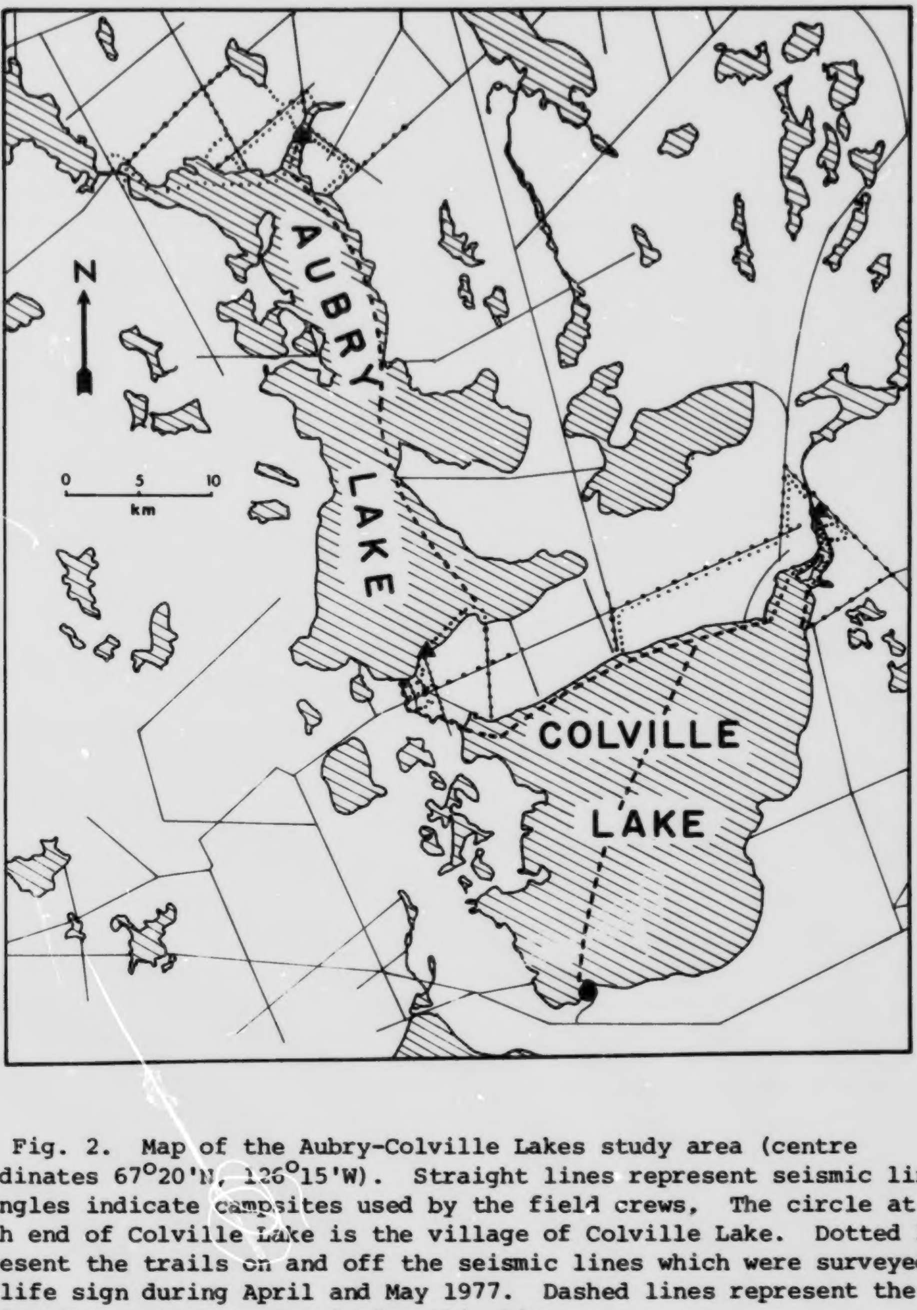

Fig. 2. Map of the Aubry-Colville Lakes study area (centre coordinates 67°20'N, 126°15'W). Straight lines represent seismic lines. Triangles indicate campsites used by the field crews, The circle at the south end of Colville Lake is the village of Colville Lake. Dotted lines represent the trails on and off the seismic lines which were surveyed for wildlife sign during April and May 1977. Dashed lines represent the field crew's other travel routes during this time.

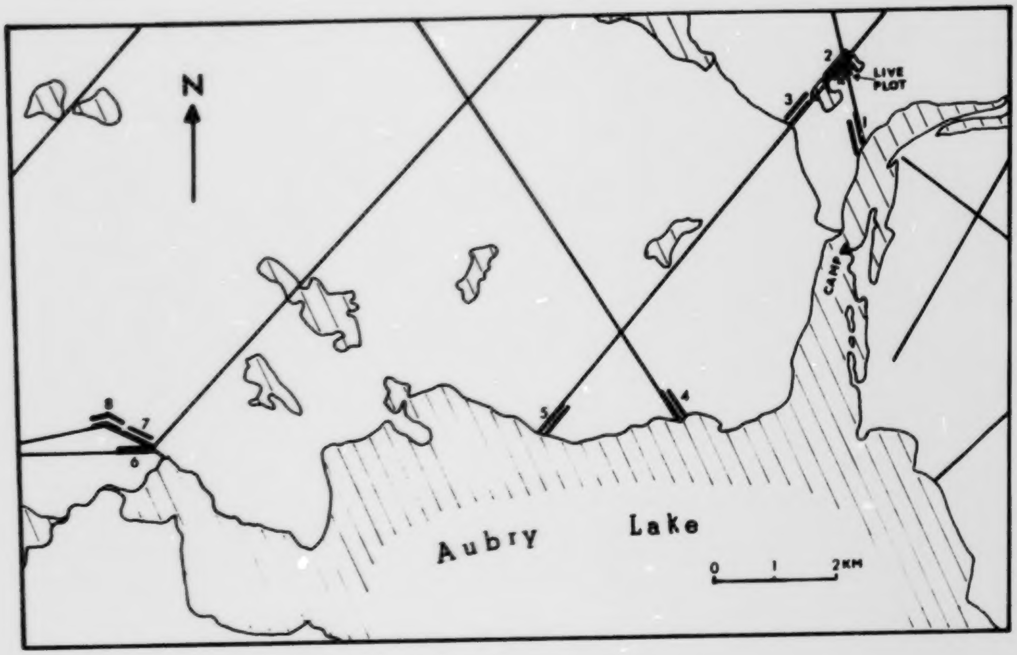
N
2
LIVE PLOT
3
1
CAMP
8
7
6
5
4
Aubry Lake
0
1
2KM

Fig. 3. Map showing the study sites at the north end of Aubry Lake. The triangle indicates the field camp. Straight lines represent seismic lines. Short heavy lines numbered 1 through 8 are the standard traplines on the seismic lines and the control traplines adjacent to the seismic lines. The live plot is the mark-recapture study plot used between 15 July and 5 August 1976.

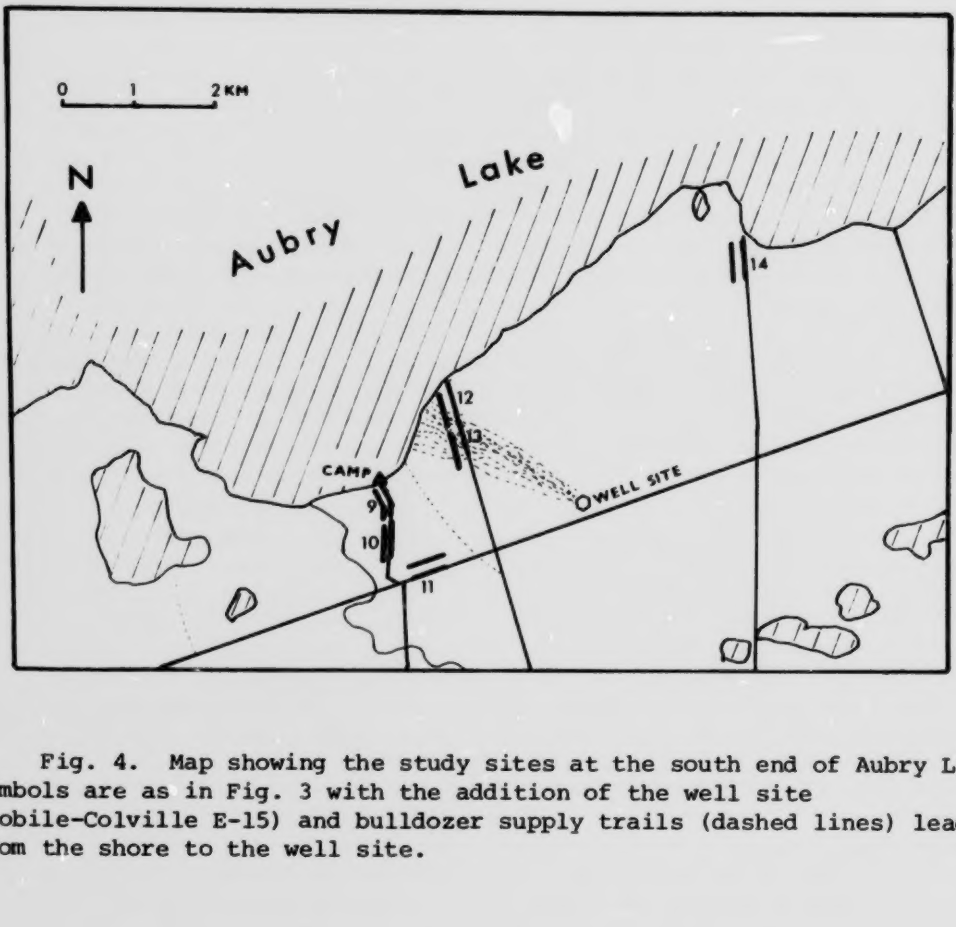
0
1
2 KM
N
Aubry Lake
CAMP
9
10
11
12
13
14
WELL SITE

Fig. 4. Map showing the study sites at the south end of Aubry Lake. Symbols are as in Fig. 3 with the addition of the well site (Mobile-Colville E-15) and bulldozer supply trails (dashed lines) leading from the shore to the well site.

### 2.2.2 Physiography of the Study Area

Aubry Lake (centre coordinates 67°25'N, 126°25'W), which lies approximately 85 km north of the Arctic Circle and 150 km northeast of Fort Good Hope, N.W.T., is situated in the northern part of the Colville Hills subdivision of the Interior Plains province (Bostock, 1964). The Colville Hills subdivision is an upland with lake-filled depressions separated by rolling hills which form a net-like plan with meshes 15 km or more. The large lakes and lower-lying ground within the ridges are about 250 to 300 m ASL, while the serpentine ridges have summits which occasionally reach 650 m ASL. The upland is an area of Paleozoic sediments (Douglas *et al.*, 1973).

The tallest hill in the area, 617 m ASL, lies 25 km due west of Colville Lake. In the immediate vicinity of Aubry Lake, the most prominent hills are those at the south end of the lake in the Colville Ridge which rises to 406 m ASL. The Colville Ridge, which runs east-northeast, is tentatively interpreted by Cook and Aitken (1971) as an anticlinal ridge. The Aubry Lake area is heavily mantled with glacial sediments, and bedrock outcrops are exceedingly rare.

Aubry Lake is a deep oligotrophic lake fed by numerous small creeks draining from the surrounding bogs, ponds and small lakes. The lake is fed by only one notable stream 15 to 20 m wide from Canso Lake to the northwest of Aubry Lake. In turn, Aubry Lake provides only one notable stream draining into Colville Lake. Colville Lake, also an oligotrophic lake fed by small streams, is drained by a single river at its northeast end.

### 2.2.3 Climate of the Study Area

The Aubry-Colville Lakes region possesses a cold dry subarctic climate. According to the N.W.T. Department of Information, the yearly average temperature is -7.5°C; the July mean high and low rise to 22.9°C and 7.6°C, respectively, while the January mean high and low dip to -25.6°C and -34.4°C, respectively. The annual precipitation is only 266.7 mm, about half of which falls as rain (147.3 mm) and the remainder as snow (1,150.6 mm). There are about 360 hours of daylight from December through February, 1,000 hours from March through May, 2,100 hours from June through August and 1,400 hours from September through November.

### 2.2.4 Habitats in the Study Area

There are seven natural types of terrestrial habitats in the study area defined by the dominant vegetation. An eighth habitat category has been established to include all sites disturbed by human agents. For a complete listing of all vascular plants in each habitat type, see Appendix 6.1.

### 2.2.5 Wildlife in the Study Area

About twenty species of waterfowl migrate through the Aubry-Colville region; several species also nest but in smaller numbers. The more notable species which breed here include the common loon (*Gavia immer*), whistling swan (*Olor columbianus*), Canada goose (*Branta canadensis*), oldsquaw (*Clangula hyemalis*), scaup (*Aythya* spp.) and red-breasted merganser (*Mergus serrator*). There are only two upland game birds, the spruce grouse (*Canachites canadensis*) and willow ptarmigan (*Lagopus lagopus*); the former is relatively uncommon but ptarmigan are abundant, especially in the winter when large flocks migrate into the area.

Five species of small mammals were recorded from the Aubry Lake area: meadow vole (*Microtus pennsylvanicus*), chestnut-cheeked vole (*M. xanthognathus*), red-backed vole (*Clethrionomys rutilus*), brown lemming (*Lemmus sibiricus*) and masked shrew (*Sorex cinereus*). Red-backed voles are by far the most common species present.

Snowshoe hares (*Lepus americanus*) were at a low point in their population cycle during this study. Red squirrels (*Tamiasciurus hudsonicus*) were also relatively uncommon; less than a dozen where noted during the two summers, but their sign was observed more frequently in the snow during the spring. Muskrat (*Ondatra zibethicus*) and beaver (*Castor canadensis*) are scarse in the area. The shores of Aubry and Colville Lakes, which for the most part are composed of coarse-grain sand, gravel or boulders, provide little habitat for muskrat and beaver. The smaller ponds and streams provide far more suitable habitat for these aquatic fur-bearers, but even here they are uncommon. Marten, mink (*Mustela vison*), short-tailed weasel (*M. erminea*), red fox (*Vulpes vulpes*) and black bear (*Ursus americanus*) are the most common year-round fur-bearers. Arctic fox (*Alopex lagopus*) occasionally invade this region in large numbers during the winter; the winter of 1976-77 was one of those winters. Lynx (*Lynx canadensis*), otter (*Lontra canadensis*), wolverine (*Gulo gulo*) and grizzly bear (*Ursus arctos*) are comparatively rare or uncommon. Wolves (*Canis lupus*) occupy the region; their sign is particularly evident when they associate with the Bluenose caribou (*Rangifer tarandus*) herd which overwinters in the Aubry-Colville area. Compared to the thousands of caribou which overwinter in the area, moose (*Alces alces*) are definitely uncommon.

# 3. METHODS

## 3.1 Floral and Disturbance Studies

### 3.1.1 Botanical Collections

An extensive collection of vascular plants (449 specimens; Appendix 6.1) and lichens (200 specimens; Appendix 6.2) was made. Representative mosses (45 specimens; Appendix 6.3) were also collected.

Most of the vascular plants were identified by the field crew and verified by Gloria Keleher, Curator of the University of Manitoba Herbarium. Dr. George W. Argus of the National Museum of Canada identified the willows (*Salix* spp.). Voucher specimens of the vascular plants have been deposited in herbaria at the University of Manitoba, Arizona State University and the National Museum of Canada (*Salix* spp. only).

Lichens were identified by Janet Marsh. Voucher specimens have been retained at the herbaria at the University of Manitoba and Arizona State University. Mosses have been identified by Dr. Royce Longton at the University of Manitoba, and voucher specimens are available from that university.

### 3.1.2 Vegetative Analysis Techniques

The vegetation of seismic lines and open spruce-lichen forests was compared on 14 seismic lines and their adjacent undisturbed forested control areas in the Aubry Lake region. Sampling took place along the snap traplines used in the small mammal survey (see Section 3.2.1). Eight seismic lines and their controls were located at the north end of the lake (Fig. 3), while six lines and controls were studied at the south end (Fig. 4). Seismic lines 1 through 6 at the north end were cut in March 1975, lines 7 and 8 also at the north end in the winter of 1973-74 and lines 9 through 14 at the south end in the late winter and early spring of 1969.

Vegetative sampling of the shrubs and trees was accomplished by application of the point-quarter technique (Cottam and Curtis, 1956). This method was employed along the snap traplines both on the seismic lines and in the open spruce-lichen forest parallel and 100 m in from the seismic lines. Data obtained from these lines allow the determination of total density for all shrub and tree species. Also, the relative density, the relative dominance, the relative frequency and the importance value for each species was calculated using the following equations (Phillips, 1959):

Density or number of individuals/ha = 10,000/(average point-to-plant distance)$^2$

Relative density = number of individuals of the species x 100/number of individuals of all species

Relative dominance = total areal coverage of the species x 100/total areal coverage of all species

Relative frequency = number of points of occurrence of the species x 100/number of points of occurrence of all species

Importance value = relative density + relative dominance + relative frequency

The line intercept method of determining cover (Canfield, 1941) was employed to sample the half-shrub and ground-layer vegetation. This method was applied at regular intervals of 21 m along the traplines and in the small mammal study plot (see Section 3.2.1). On the lines at the north end of Aubry Lake, a line transect 3 m in length was extended, and the species and extent of those individuals which were under- and over-lying the tape were recorded. The length of the tape covering detritus (earth, rocks and debris) was measured. At the south end of Aubry Lake, a 10-m line transect was laid across the seismic line so that the midpoint of the tape measure coincided with the midpoint of the seismic line. Transect lines were determined at 100-m intervals along the snap traplines. The individual species and plant cover data above and below the tape were determined and recorded.

Line transects were used to sample percentage cover of the individual species of half-shrubs and ground vegetation rather than quadrats since the vegetative cover in some areas was very dense, especially the shrubby species such as alder (*Alnus crispa*), Labrador tea (*Ledum* spp.), willow (*Salix* spp.) and blueberry (*Vaccinium uliginosum*). Measuring cover and counting individuals under these circumstances would have been extremely difficult.

In addition, quadrats 3 m$^2$ in size were placed on one side of the line transects at the sites on the north end of Aubry Lake and on seismic lines 9 and 10 at the south end. All species present in each quadrat were recorded and ranked on a total estimate scale of cover and abundance according to the system of Braun-Blanquet (1932). Presence-absence data of the plant species in various habitats were obtained from these quadrats as well as importance values calculated by summing the ranked values for each species in each specific habitat and dividing this result by the total number of quadrats in each habitat in which the species occurred.

Density of white spruce (*Picea glauca*) was determined in the open spruce-lichen forest on the small mammal study plot by sampling 19 10-m$^2$

quadrats (Phillips, 1959). All individuals over 1.37 m in height were counted in each quadrat, and 90 trees of large and small circumferences were cored to determine the approximate age of the stand.

### 3.1.3 Subsidence Measurements

In conjunction with the botanical study, measurements were taken on thermokarst and erosional subsidence along the seismic lines and the bulldozer supply trails cut in late winter and early spring of 1969 on the south end of Aubry Lake (Fig. 4). Eighty traverse lines of 14 to 42 m in length were run perpendicular to the seismic lines at regular 50-m intervals; these traverse lines were laid across the seismic lines along snap traplines 9 through 14. Four additional traverse lines were run perpendicular to the Cat trails. All traverse lines extended from undisturbed habitat, across berm and cut lines and on into undisturbed habitat on the other side of the lines. Plumb readings were taken along the traverse lines at 1-m intervals (Fig. 5). The widths of the undisturbed, cut line and berm portions of the traverse lines were noted. The subsidence measurements taken over each of these three ground conditions were averaged for each set of traverse lines crossing a seismic line or supply trail. The average figures, in turn, were used to calculate the average subsidence along each line.

## 3.2 Wildlife Studies

### 3.2.1 Small Mammal Trapping Techniques

#### 3.2.1.1 Summer 1976

In order to determine the effects seismic lines have upon small mammal populations, 14 standardized traplines were established along the various-age seismic lines. These traplines were designated lines 1A through 14A. Control traplines were set in undisturbed habitats about 100 m to one side of the seismic lines; the control lines were designated lines 1B through 14B. For the locations and botanical descriptions of these traplines, see Figs. 3 and 4 and Appendix 6.4. Both A and B traplines were 500 m in length and had 70 Museum Special snap traps at 7-m intervals. A mixture of peanut butter, chopped raisins, bacon grease and rolled oats was used as bait. Each trapline was set for six nights and checked daily. Thus, each A and B trapline was used for 840 trap nights (TN), giving a total of 11,760 TN for the 14 lines and their controls.

Fig. 5. A plumb reading being taken along a traverse line which crosses a 1969-cut seismic line.

A total of 268 small mammals were collected from the 14 standard traplines and their controls (Fig. 6). The following data were obtained from each specimen: species, sex, breeding condition, age, weight, location and date. All skulls were preserved but only half of the skins were prepared as museum specimens. The skulls and skins have been deposited in the collection of the Manitoba Museum of Man and Nature in Winnipeg.

In order to gain information on the effects of seismic lines on small mammal home ranges and movements, a live-trapping programme was initiated; this mark-recapture programme was conducted from 15 July to 5 August 1976 on a 14-m x 14-m grid plot established near the north end of Aubry Lake (see Fig. 3). The plot was situated on an open white spruce-lichen forest at the edge of a small thermokarst pond. Two seismic lines, cut in March 1975, crossed one another on the plot (Fig. 7). The plot originally had 19 columns with 10 rows of trapping stations in each and covered 2.85 ha. It was soon obvious that most of the voles were being captured at least a few times on the periphery of this plot, indicating that their home ranges most likely extended beyond the plot. In hopes of completely encompassing at least some of the voles' home ranges, the plot was extended on 26 July by three rows of all sides except the one bordering the pond. From 26 July to 5 August traps were set on these outer three rows as well as along the entire lengths of the seismic lines on the plot, thus covering a total of 5.57 ha.

After the plot was closed, 38 live traps were placed within 30 m of the outside edge of the plot for two nights in order to catch voles for the cafeteria feeding trials. Three marked voles from the plot were captured in these traps; these sites have also been used in calculating the voles' home ranges.

During the 21-day trapping period on the plot, 168 Sherman folding aluminum live traps (7.5 cm x 7.5 cm x 22.5 cm) were set for a total of 3,528 TN. Each trap was baited with the snap trap bait plus a few slices of dried apple. The traps were furnished with Terylene fibre for nesting material. The traps were either placed in the shade or covered with moss or lichen. Traps were checked twice daily. A total of 99 small mammals were captured on the plot. Every animal was toe-clipped and released at the capture site. The following data were recorded each time an animal was captured: toe-clip identification number, species, sex, breeding condition, age (adult or juvenile), capture site, date and time of day.

Exploratory traplines employing both kill and live traps were set for an additional 1,344 TN in various habitats while searching for small mammal populations; 42 small mammals were captured with this effort. These specimens were preserved in the same manner as those taken on the standard snap traplines.

### 3.2.1.2 Summer 1977

In order to determine whether small mammals react in the same manner

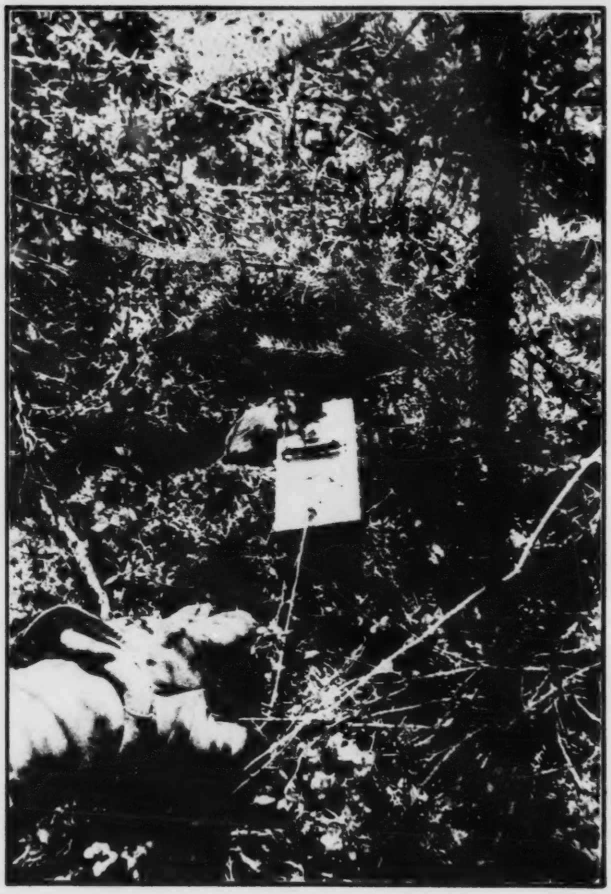

Fig. 6. A brown lemming captured in a Museum Special trap. These traps were used on the standard traplines as well as on the exploratory kill traplines.

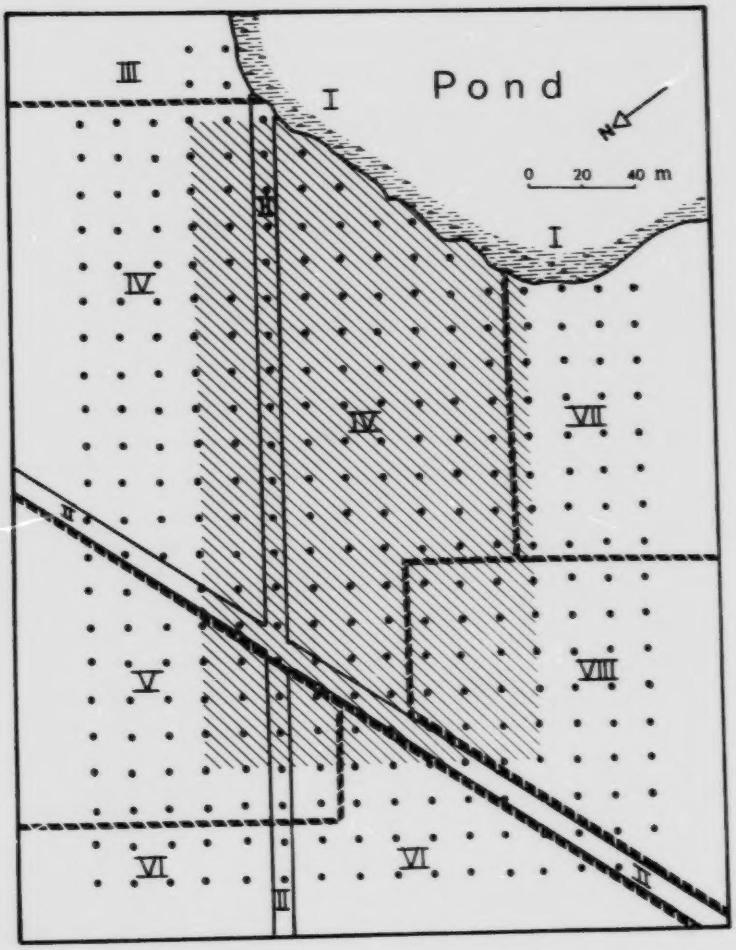

Fig. 7. Small mammal mark-recapture study plot located near the north end of Aubry Lake at 67°36'N, 126°30'W. The plot bordered a small thermokarst pond and was crossed by two seismic lines cut in March 1975. Each dot represents a trap station. The shaded area in the centre of the plot indicates the initial 2.85-ha plot utilized between 15 and 26 July 1976. The surrounding trap stations, which expanded the plot to 5.57 ha, were added on 26 July and were used until 5 August 1976. Trap stations along the seismic lines in the central shaded portion of the plot were used during both trapping periods. Numbered areas separated by dashed lines represent different vegetation zones (see Section 4.2).

to seismic lines during different phases of their population cycle, nine standard traplines were retrapped in 1977. Between 3 and 24 August 1977 traplines 1A and 1B through 6A and 6B at the north end of Aubry Lake and 9A and 9B through 11A and 11B at the south end were retrapped. The methods used were identical to those employed in 1976.

### 3.2.2 Vole Food Preference Tests

In order to ascertain which components of the local flora are important items in the voles' diets and to assist in analyzing their habitat requirements, cafeteria food tests were conducted following the techniques employed by Riewe (1973) and Thompson (1965). A majority of the vascular plants (97 of 175 species) recorded in the Aubry Lake vicinity, plus seven non-vascular plants, were offered to eight red-backed voles, two chestnut-cheeked voles and one meadow vole. A total of 72 tests were conducted between 29 July and 13 August 1976.

The voles were caged individually in wire-mesh cages measuring approximately 10 cm x 15 cm x 50 cm. Terylene fibre was provided for nesting material. Water in small bowls was supplied *ad libitum.* The cages were placed on tin foil in order to catch any food scraps that might fall out during the tests. The cages were maintained at ambient temperature in a well-vented tent. At the beginning of each test, 10 to 25 species of plants were placed in each cage. Dried apple, proven microtine bait (Riewe, 1971), was supplied in excess, thereby allowing the test animals to maintain themselves on apples if they so desired and allowing for the avoidance of unpalatable plants. The results of these cafeteria feeding trials thus indicate which plants were preferred by the voles rather than which plants might be consumed under dire circumstances.

Detailed records were kept on the plant species and the amount and parts given to each vole (*e.g.*, *Vaccinium uliginosum*: 7 berries, 8 cm of roots, 95 leaves and 30 cm of branches). After 24 hours, the voles were removed from their cages, and the plants examined for feeding sign. After every test each anatomical plant part presented to the voles was assigned a preference value ranging from 0 to 3:

0 = plant part rejected by all voles

1 = plant part accepted very poorly (less than 25% consumed) by some voles and rejected by other voles

2 = variable acceptance; plant part accepted readily (75 to 100% consumed) by some voles while other voles either completely rejected or consumed less than 25%

3 = plant part readily consumed (51 to 100%) by all voles

### 3.2.3 Wildlife Track Survey

The track survey was conducted from a base camp at the northeast end of Colville Lake and from two outpost camps on Aubry Lake. During the 34 days of field work in April and May, a total of 1,362 km were traversed by snowshoes and snowmobiles. Weather conditions permitted track surveys to be made on only 15 days; it was impossible to conduct surveys on the remaining 19 days because of either overcast skies (hence poor lighting conditions), snow storms or slushy snow caused by temperatures of up to 19°C which provided support for neither snowshoes or snowmobiles.

Surveys were conducted along 72.3 km of seismic lines cut in 1969 and along 72.9 km of lines cut between 1973 and 1975. Control bush trails totalling 34.9 km were surveyed in the vicinity of the 1969 seismic lines and 39.8 km of control bush trails were surveyed near the seismic lines cut between 1973 and 1975. In addition, animal sign was recorded along 20.2 km of rivers and creeks and across 60.3 km of lakes. When surveying the seismic lines, all tracks were recorded which either crossed or followed along the 10-m wide lines. In order to have comparable results in the bush or on lakes and rivers, only those tracks which were within 5 m of either side of our trails were recorded. The majority of the lines were surveyed only once, but some were surveyed as many as four times. These lines and trails were surveyed a second, third or fourth time only after a snowfall had occurred and one or more snow-free days had elapsed; this allowed the wildlife sufficient time to leave enough sign to warrant another traverse along the line or trail. The seismic lines and their control bush trails were surveyed simultaneously by different members of the field crew in order to obtain comparable results.

## 3.3 Snow Measurements

Snow stations were established during the spring field activities according to procedures outlined in Klein *et al.* (1950). The snow kit used was a modified National Research Council of Canada kit. Snow investigations were intended to provide an accurate description of changing snow conditions that prevailed throughout the period 7 April to 10 May 1977. They were not intended to investigate specific differences in snow characteristics associated with seismic lines. However, certain peculiarities in the snow regime of the latter were noted and warrant further investigation as they appear to influence the movement behaviour of some animals.

# 4. RESULTS AND DISCUSSION

## 4.1 Description of Major Habitats

### 4.1.1 Open Spruce-Lichen Forest

White spruce forests (Fig. 8) with an understory of lichen mats and ericaceous shrubs predominate in the study area; approximately 60% of the land surface is covered with this plant community. According to Brown (1970), the area is located at the southern limit of continuous permafrost zone. Soil development was noted to vary between the different habitat types. In the spruce-lichen forest, the soils are mainly of organic material remaining moist throughout the summer.

Ground-layer vegetation reflects local environmental conditions. Lichen mats, primarily *Cladina alpestris, C. arbuscula, C. rangiferina* (reindeer lichen), *Cladonia amaurocraea, Cetraria cucullata* and *C. nivalis*, dominate the well-drained slopes of the forest. In drainage gulleys and other shaded moist areas, mosses usually replace the lichens. *Peltigera aphthosa*, a large foliose lichen, is found in association with feather mosses and Lapland cassiope (*Cassiope tetragona* ssp. *tetragona*), a half-shrub, in the wetter regions of the slopes. In shaded and moist areas and especially under shrub and spruce canopies, half-shrubs such as bearberry (*Arctostaphylos rubra*), avens (*Dryas integrifolia* ssp. *integrifolia*), crowberry (*Empetrum nigrum* ssp. *nigrum*) and lingonberry (*Vaccinium vitis-idaea* ssp. *minus*) are abundant. Forbs common among the lichen mats and moss clumps in some areas are sweet coltsfoot (*Petasites frigidus*), wintergreen (*Pyrola* spp.) and bog star (*Parnassia palustris* ssp. *neogaea*). The only areas in which grassy plants are significant in the open spruce-lichen forest are wet areas, resulting from forest floor disturbances such as animal runways and fallen trees. Sedges (*Carex* spp.) are more abundant than grasses.

Forest openings provide habitat for understory shrubs such as willows (*Salix arbusculoides, S. glauca, S. lanata* ssp. *richardsonii*) and shrub birch (*Betula glandulosa*) (Fig. 8). The ericaceous shrubs Labrador tea (*Ledum palustre* ssp. *groenlandicum*) and blueberry (*Vaccinium uliginosum*) are the dominant woody shrubs; the latter occupy most forest openings. Shrubs of lesser importance but common include shrubby cinquefoil (*Potentilla fruticosa*) and Lapland rosebay (*Rhododendron lapponicum*). A few stands of tamarack (*Larix laricina* var. *alaskensis*) were found at the south end of Aubry Lake situated in poorly drained areas of the spruce-lichen forest.

Forbs and half-shrubs, lichens and mosses comprise the most important strata in the spruce-lichen forest. None of the strata provide more than 20% of the cover, which indicates that this habitat type is not

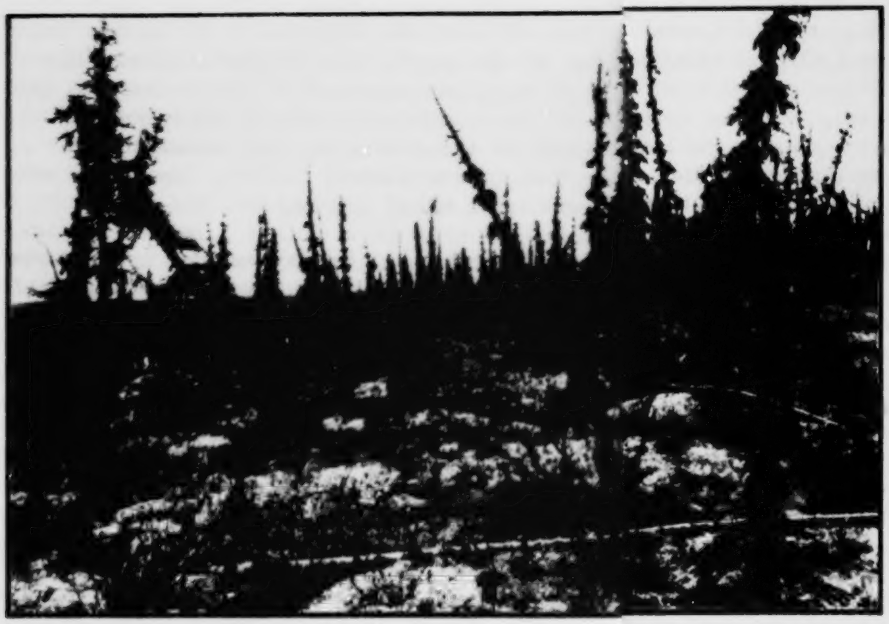

Fig. 8. Open spruce-lichen forest at the north end of Aubry Lake. The understory is dominated by shrub birch, blueberry and willows.

dominated by one particular stratum. Trees and shrubs cover 11% of the area sampled, but this figure may be low as the upper canopies are not included in the line transects from the north end of Aubry Lake.

Open spruce-lichen forests are inhabited by fairly large populations of red-backed voles which are the mainstay of marten and short-tailed weasels. In the moister areas with an understory of shrubs, the other species of small mammals augment the red-backed voles. The white spruce also provide food and shelter for red squirrels and spruce grouse as well as several passerine birds. It is the lichens and other ground cover which attract the Bluenose caribou herd to overwinter in this region. Naturally, all of the large carnivores occasionally use or traverse the spruce-lichen forest. Moose also utilize this habitat, but it is primarily the willow and alder patches scattered through the forests which are important to moose during the winter months. Snowshoe hares and ptarmigan are likewise supported by the willow patches.

### 4.1.2 Lake Shoreline

Lake shorelines (Fig. 9) which make up less than 5% of the land area are composed of two successional stages. Established shorelines support a cotton grass-sedge complex (*Eriophorum-Carex*) blending into an older band of willows and occasionally alders. *Boschniakia rossica*, a plant which is parasitic on alder roots, is found associated with the alders. Lichens and mosses are absent from the thickets because of litter accumulation from the deciduous alders. Sandy and rocky younger shorelines or those exposed to ice-pack abrasion in the spring support a sparse vegetative cover of various herbs which establish themselves in disturbed areas, for example, wormwood (*Artemisia Tilesii*), fireweed (*Epilobium angustifolium*), river beauty (*E. latifolium*) and fleabane (*Erigeron elatus*).

The short spike rush (*Eleocharis acicularis*) is especially abundant along lake shorelines with a great volume of decomposed organic material. Clumps of marsh fleabane (*Senecio congestus*) and mats of crowfoot (*Ranunculus confervoides*) and creeping spearwort (*R. repans*) are also common in these areas.

The cotton grass-sedge complex provides habitat for several ground-nesting birds, especially whistling swans, oldsquaws, lesser yellowlegs (*Totanus flavipes*) and tree sparrows (*Spizella arborea*) as well as for isolated populations of microtines. During the summer the shorelines are used as travel routes by moose and as travel and hunting routes by several predators, especially black bear and mink. The willows and alders provide important feeding areas for ptarmigan, hare and moose in the winter. These herbivores, in turn, attract weasels, mink, arctic and red foxes and wolves to the lake shorelines.

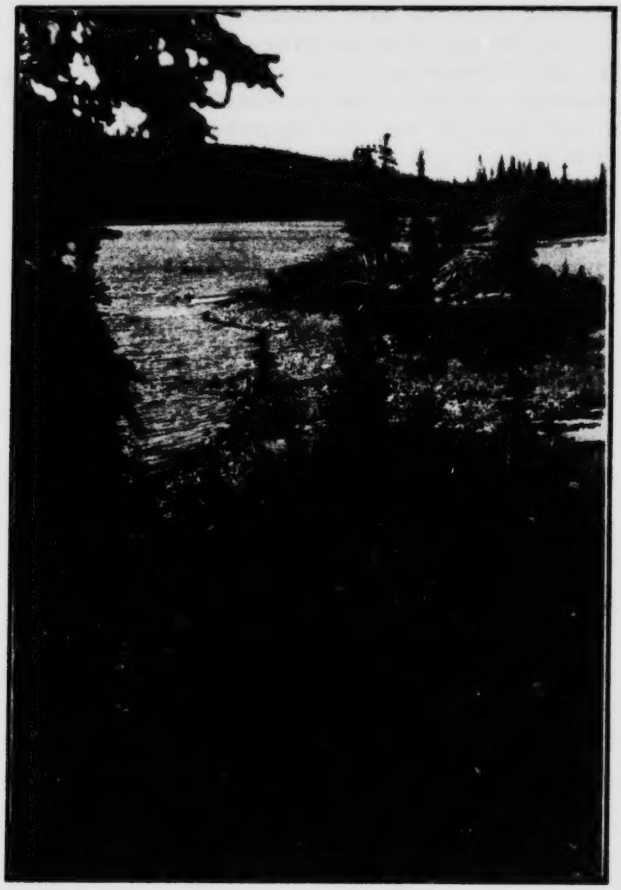

Fig. 9. Sand-and-cobble beach at the north end of Aubry Lake. Above the exposed beach, the cotton grass-sedge community blends into a narrow strip of alder and willow and then into the dominant open spruce-lichen forest.

### 4.1.3 Pond and River Margins

Pond and river margins (Fig. 10) are about 10 m wide and blend into the surrounding vegetation type, usually open spruce-lichen forest. The sedge *Carex aquatilis* is the most common species growing at the water's edge. Pockets of mare's tail (*Hippurus vulgaris*) are abundant in the shallows, and pondweeds (*Potamogeton* spp.), horsetail (*Equisetum fluviatile*), water lily (*Nuphar variegatum*) and marsh fivefinger (*Potentilla palustris*) are also common in the shallow water.

Wet humic ground just above the water level is most often occupied by northern water carpet (*Chrysosplenium tetrandrum*), willow herb (*Epilobium davuricum*), bedstraw (*Galium trifidum*), chickweed (*Stellaria crassifolia*) and sandwort (*Minuartia dawsonensis*). Mosses form a ground-cover mat underneath the sedges in most pond margins. The liverwort *Marchantia* sp. occupies shaded wet areas on humic soil.

Pond and river margins which are drying up support shrub birch, cassandra (*Chamaedaphne calyculata*), sweet gale (*Myrica gale*) and willow. Margins with a great amount of waterfowl feces support willow herb, cotton grass, willow (*Salix alaxensis*) and marsh fleabane. Mosses form an understory for sedges in wet areas. Lichens, on the other hand, are absent from this habitat type; fluctuating water levels will not permit these plants to become established.

Pond and river margins cover a relatively small percentage of the land area, probably less than 2%, but this habitat is considerably more important than it might appear. Moist sedge margins provide excellent habitat for populations of meadow voles and chestnut-cheeked voles as well as for several species of waterfowl and shorebirds. This habitat provides moose with summer feeding and loafing areas as well as food and shelter for muskrat and beaver. Mink, weasel, otter and fox hunt extensively along these pond and river margins.

### 4.1.4 Fens and Bogs

Fens (Fig. 11) are dominated by sedges (*Carex* spp. covered 37% of the fens sampled), whereas bogs are dominated by *Sphagnum* mosses. Both fens and bogs succeed ponds. Wetter bogs have a complete ground cover of moss (mosses covered 52% of the bogs sampled), and drier bogs are interspersed with *Sphagnum* hummocks. These hummocks have a definite flora of their own, principally shrubs and half-shrubs such as bog rosemary (*Andromeda polifolia*), cassandra, Labrador tea, cloudberry (*Rubus chamaemorus*), cranberry (*Oxycoccus microcarpus*), the willow *Salix arctophila*, lingonberry and the sedges *Carex capitata* and *C. limosa*. Lichens are virtually absent except for the white crustose species *Icmadophila ericetorum* which grows flat against the *Sphagnum* in small pockets on the hummock tops. Depressions between the hummocks mainly support sedges. Trees and shrubs (shrub birch and willows), sedges and

Fig. 10. Pond margin surrounding a small shallow thermokarst pond near the north end of Aubry Lake. The botanist and assistant are recording vegetation data from a 3-m x 3-m quadrat. The small mammal mark-recapture plot is located on the far side of this pond.

Fig. 11. Fen with open spruce-lichen forest in the background. Sedge tussocks and *Sphagnum* hummocks are common in this fen.

lichens each cover less than 10% of the raised *Sphagnum* hummocks.

The next successional stage after the hummocky stage is characterized by shrub birch and willows, provided the active layer of permafrost has increased in depth through litter accumulation and can support shrub growth.

Most fens and bogs near Aubry Lake are not very large, but there are extensive ones surrounding the shores of Colville Lake. These moist habitats cover approximately 10 to 15% of the study area. Open fens and bogs support little in the way of wildlife; however, closed fens with stunted spruce, willow and alder often possess comparatively dense microtine and shrew populations.

### 4.1.5 Lichen Heath

Lichen heaths (Fig. 12) are covered primarily by lichens (lichens covered 36% of the areas sampled). The dominant lichens are the yellow terricolous *Cladina* spp. of which *C. alpestris, C. arbuscula* and *Cladonia amaurocraea* are most abundant. *Cladina rangiferina, Cetraria cucullata, C. islandica* and *C. nivalis* are also profuse in the lichen associations. Ericaceous shrubs, especially Labrador tea, are second in importance to lichens and cover 30% of the heath areas; they are found between and on the sides of *Sphagnum* hummocks. Lingonberry is plentiful in the shade underneath the Labrador tea. Cloudberry is abundant on exposed hummock tops. Mosses of the cushion growth-form are found on shaded hummock sides. Solitary white spruce are standing relicts of previous fires.

Lichen heaths can develop into a shrub birch seral stage and thence to a mature spruce-lichen forest as evidenced in some of the areas surveyed. Other lichen heaths, especially in the more hummocky areas, are shallowly underlain with permafrost and tend to resist succession.

Lichen heath areas are scattered throughout the study area. They are neither very prevalent (they cover probably less than 5% of the area) nor are they very large. They are usually found on low-lying level ground, on a point of land or covering an exposed site. Lichen heaths are utilized by caribou bands in the winter, but most other wildlife species rarely use them.

### 4.1.6 Crowberry Heath

Crowberry heaths (Fig. 13) are open, sparsely vegetated areas dominated by mats of *Empetrum nigrum*. One of these barren areas is located on an esker at the north arm of Aubry Lake, and another such area is situated about 2 km south of the first. These Aubry Lake barrens are the result of fire a number of years ago. In the Mackenzie Delta

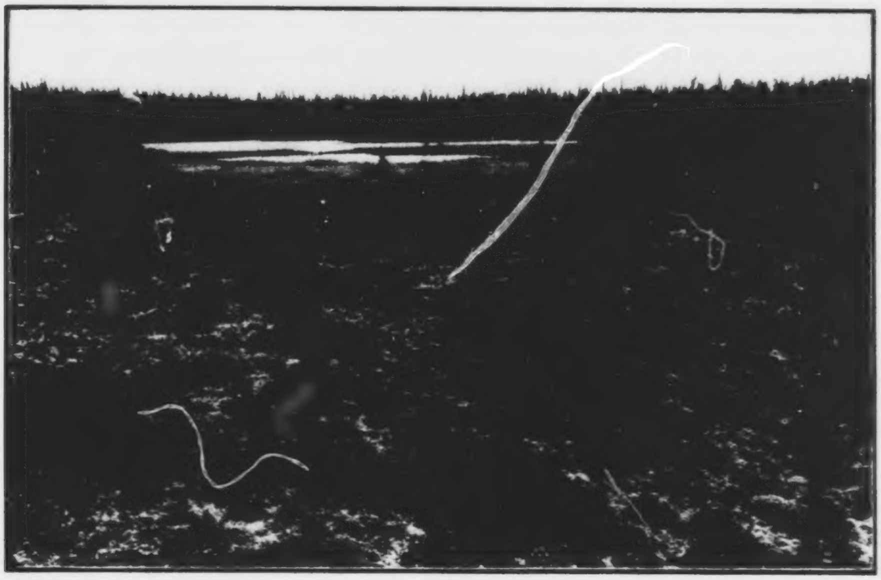

Fig. 12. Small lichen heath on the edge of Aubry Lake. This heath blends into a fen and open spruce-lichen forest in the background.

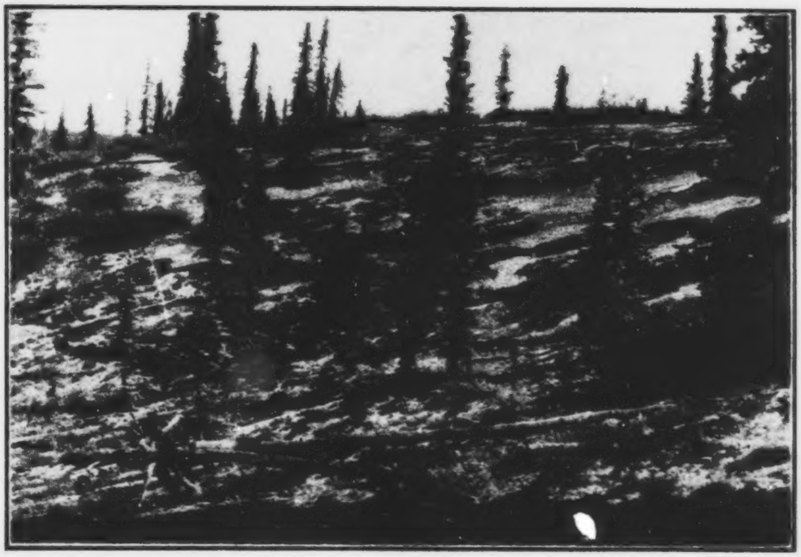

Fig. 13. Crowberry heath on an exposed esker at the north end of Aubry Lake. The remains of charred trees indicate this is a seral stage caused by fire.

area, according to Gill (1973), secondary succession of low Arctic tundra moss, lichen and heath species has taken place on extremely exposed sites that have been cleared of trees and shrubs; the northwest-facing crowberry barren noted above from Aubry Lake is an example of such an exposed site. Shrub birch and blueberry establish themselves in the more wind-protected areas of the barrens.

Crowberry heaths are quite small and cover considerably less than 1% of the study area. These small heaths show signs of winter caribou use but otherwise appear to be of little importance to wildlife.

### 4.1.7 Natural Subsidence

Mudflows, as described by Lambert (1972, 1976) tend to occur on sloping surfaces where the active layer is thick and where silt-rich soils with high ice content are overlain by peat. These thermokarst features often develop along shorelines where wave action or rafting ice erode away the vegetation exposing the substrate to greater heat penetration. Once the substrate thaws, the mud flows downhill. As the subsurface slumps it creates a massive scar with a headwall often extending several metres above the semicircular mudflow. Islands of vegetation are scattered throughout the mudflow. The secondary succession which takes place on these subsidences has been described by Lambert (1976). Along the shores of Aubry Lake where these mudflows are common (Fig. 14), wormwood, fireweed and marsh fleabane are important colonizers.

These natural thermokarst areas cover less than 1% of the study area and do not appear to be important to wildlife.

### 4.1.8 Disturbed Sites

#### 4.1.8.1 Oil Drilling Site

One abandoned oil drilling site (Mobile-Colville E-15) is located in the study area near the top of Colville Ridge at the south end of Aubry Lake. The oil well was spudded on 18 April 1970 and abandoned on 18 October of that same year. Several plant species are found only at this site growing in the gravelly soil; these species include yarrow (*Achillea sibirica*), goosefoot (*Chenopodium Berlandieri* ssp. *Zschackei*), pale corydalis (*Corydalis sempervirens*) and raspberry (*Rubus idaeus*). These species were probably introduced by track vehicles working at the drilling site.

Fig. 14. A natural thermokarst landslip along the north shore of Aubry Lake. Clumps of vegetation from the surrounding spruce-lichen forest are evident in the mud flow.

### 4.1.8.2 Track Vehicle Trails

Trails were bulldozed through the open spruce-lichen forest during the late winter and early spring of 1969 to transport supplies to the oil drilling site at the south end of Aubry Lake (Fig. 15). It appears that these trails were haphazardly blazed with no planning whatsoever. Because the insulative ground layer was disturbed on these trails, thermokarst has occurred, causing considerable slumping in the middle of the trails. Spruce have had their roots undercut, and soil has washed away by downhill drainage and, particularly, spring runoff. The trees thus are leaning to one side. Lush growths of grasses, mainly reed bent grass (*Calamagrostis purpurascens*), are confined to these track trails.

### 4.1.8.3 Native Camps

Native campsites of seasonal use are scattered throughout the study area. Winter camps are easily identified since the trees are chopped 0.5 to 1 m above ground level, corresponding to the snow accumulation in the forest at cutting time. Clearings in the spruce-lichen forest resulting from these camps have opened habitats for such shrubs as alder, shrub birch, willows, blueberry and various species of grasses.

Permanent fishing camps with cabins are located on the south shore of Aubry Lake (Fig. 16) and along the north shore of Colville Lake. Vegetation disturbance is great in the vicinity of the buildings and in places where dogs have been tethered. Fireweed flourishes especially where the dogs have been tied. Shrub birch has invaded areas where disturbance has been less over the past few years.

### 4.1.8.4 Seismic Lines

Seismic lines of different ages show different characteristics regarding thermokarst subsidence and vegetation. The older lines, cut in 1969 and located at the south end of Aubry Lake, are reflexed toward their centres (see Section 4.3.3). The probable reason for this slumping on the older seismic lines is the fact that mushroom shoes were not used on the bulldozer blades for protection of the insulating ground layer. Grasses are abundant throughout the length of seismic lines where slumping has occurred (Fig. 17). Pond margin species such as northern water carpet, river beauty (*Epilobium latifolium*), marsh fleabane and chickweed are established in the wet humic soil. In addition, deep thermokarst pools are habitat for mats of crowfoot (Fig. 18). Tussocks of cotton grass flourish in the moist areas between the wet sections dominated by cotton grasses and the dry sections dominated by grasses. The moist-to-wet sites also support willows. Three to four year-old white spruce saplings are plentiful on the dry hillslopes of lines where thermokarst erosion has not occurred (Fig. 19).

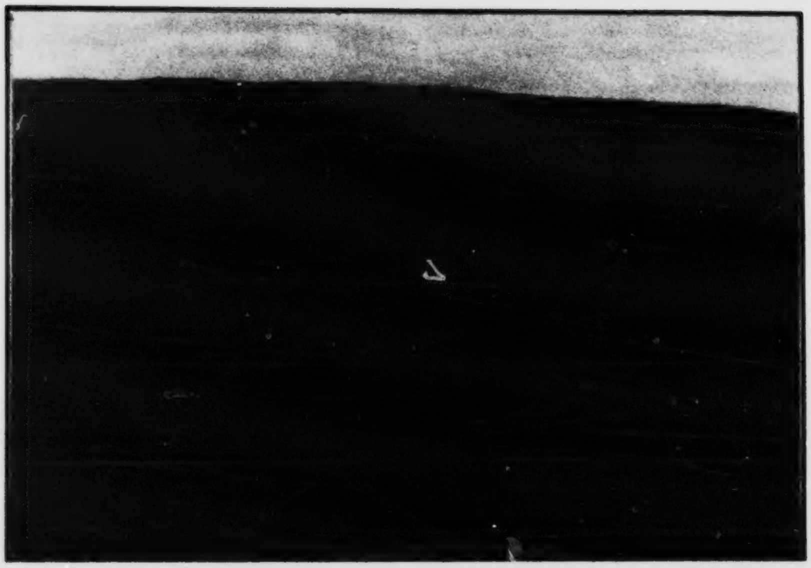

Fig. 15. Aerial view looking southeast along bulldozer supply trails leading to Mobile-Colville E-15 drilling site at the south end of Aubry Lake.

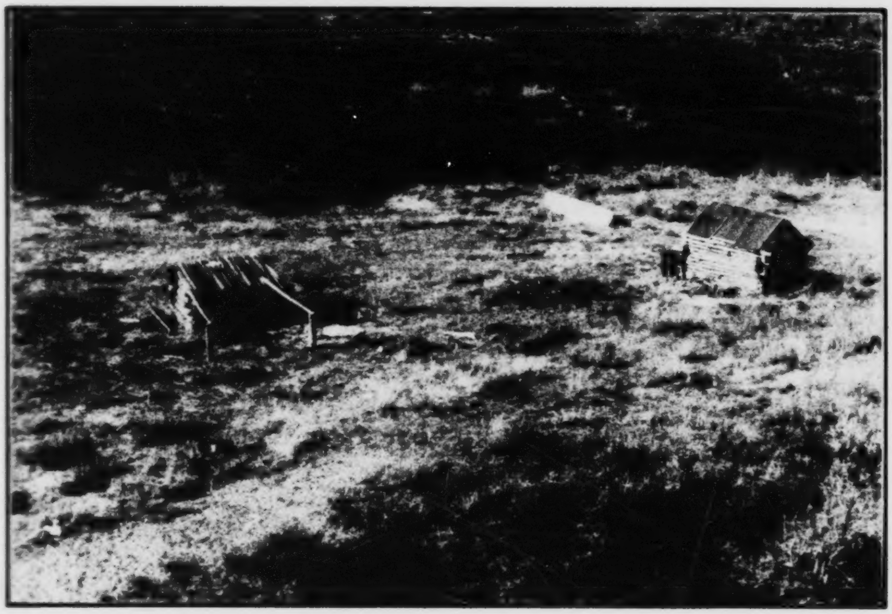

Fig. 16. Native fishing camp at the south end of Aubry Lake. This camp is used in autumn when white fish (*Coregonus clupeaformis*) migrate into the river draining Aubry Lake into Colville Lake.

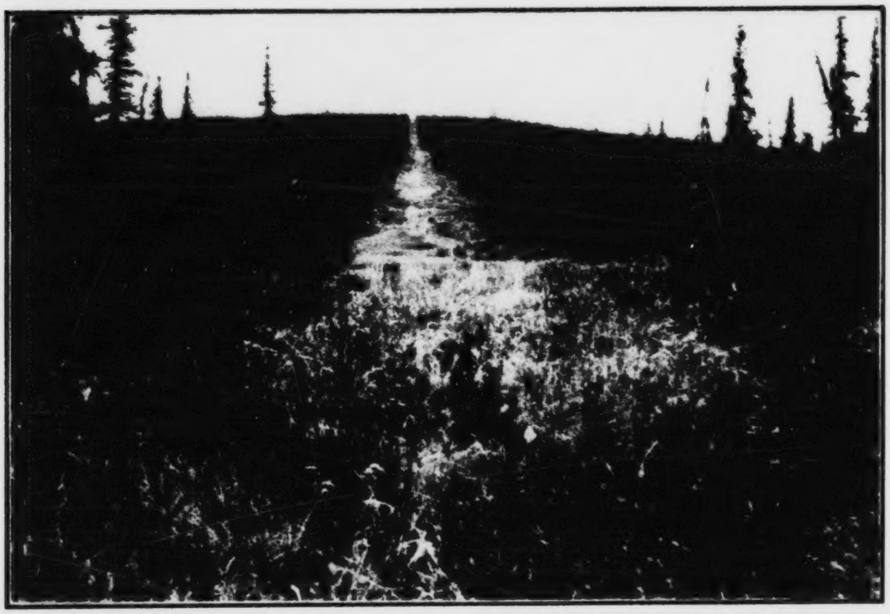

Fig. 17. Looking east along seismic line 11 at the south end of Aubry Lake. This 1969-cut line is now dominated by grasses, sedges, forbs and half-shrubs.

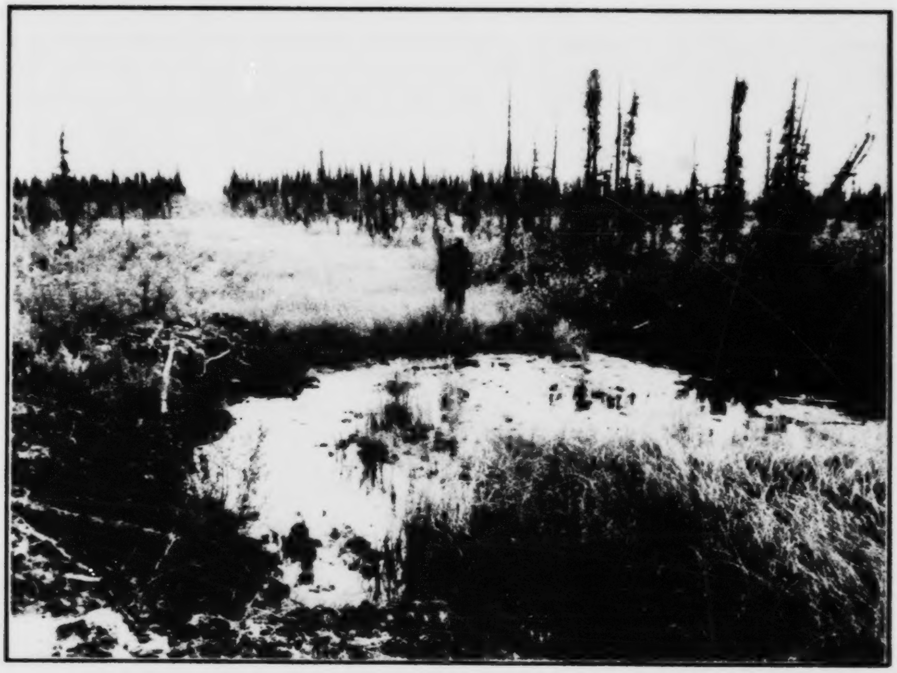

Fig. 18. Termokarst pool on a seismic line cut in 1969 near the south end of Aubry Lake. The line has been invaded by a lush growth of grasses and sedges. The pool provides habitat for bladderwort (*Utricularia intermedia*), mare's tail and crowfoot.

Fig. 19. Seismic line cut in 1969 on the south slope of Colville Ridge. This portion of the dry slope is dominated by shrub birch and willows.

The recent seismic lines cut in the spring of 1975 utilizing the mushroom shoes do not exhibit the successional trends evident in the older lines (Fig. 20). The only areas in which thermokarst is apparent are isolated pools where the insulative layer was inadvertently disturbed. The growth of willow sucker shoots is well-established on most recent seismic lines. The development of new shoots of the ericaceous shrubs Labrador tea, blueberry and Lapland rosebay is apparent. Flowering forbs are abundant in the spring and early summer on these lines. They tend to prefer the well-drained slopes rather than the level wet areas. The more abundant forbs are anemone (*Anemone parviflora*), gentian (*Gentiana propinqua*) and ragwort (*Senecio lugens*). Grasses and sedges are sparse on these younger seismic lines. Lichen and moss mats are somewhat damaged and in a secondary successional stage.

## 4.2 Description of Habitats on the Mark-Recapture Plot

Based on sampling of vegetation and age and density studies of white spruce stands, the mark-recapture plot is divided into eight areas (Fig. 7).

I. This area includes only the pond margin; see Section 4.1.3 for a description of this habitat.

II. This area includes the two seismic lines cut in March 1975; see Section 4.1.8.4 for a description.

III. This small area in the northeastern section of the plot contains the oldest average age trees (211 years), with an average density of 9 trees/10-m$^2$ quadrat. The percentage detritus accumulation of ground cover is low, also indicating a more mature forest stand. Lichens and mosses form the ground cover layer with species such as bearberry, dryas, crowberry and lingonberry. The shrub layer, which is usually identified with forest openings and younger forested areas, is virtually absent from this mature spruce stand.

IV. The largest habitat type on the plot occupies the central and northwestern areas. White spruce trees are of the smallest average circumference (13 cm) and the youngest average age (67 years). The average number of trees by 10-m$^2$ quadrat is 20, indicating an immature forest with many small-diameter trees. The soils of this area contain a greater amount of moisture, with *Sphagnum* moss being dominant. Shrub birch, dryas, horsetail (*Equisetum scirpoides*) and willows are abundant throughout the area.

V. This area, located in the northwestern section of the plot, is characterized by having the least average number of trees

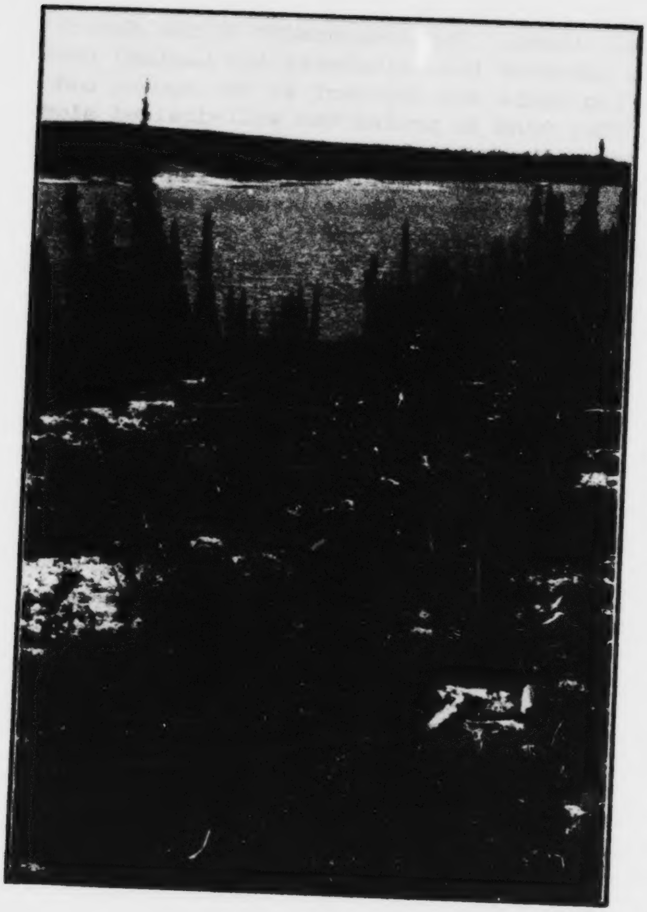

Fig. 20. Seismic line at the north end of Aubry Lake cut in March 1975. These newer lines show little evidence of thermokarst activity.

(5/10-$m^2$ quadrat); the average age of the trees is 145 years. Species favouring open areas such as Labrador tea and marsh fivefinger are found here. Bitter cress (*Cardamine hyperborea*), a forb of relatively rare occurrence in the study area, grows in this area. *Sphagnum* moss is an important ground cover component.

VI. Located at the western end of the plot, area VI has an average of 7 trees/10-$m^2$ quadrat, average tree age of 86 years and average tree circumference of 16 cm. This area has a more heath-like appearance than the other areas, with *Sphagnum* hummocks covering a high percentage of the ground area. Sedges, blueberry and shrub birch are important species between the hummocks, while crowberry, lingonberry, bearberry and the willow *Salix myrtillifolia* grow on the hummocks. The horsetail *Equisetum arvense*, which has an affinity for wet habitats, and the prostrate netted willow (*Salix reticulata* ssp. *reticulata*) are found only in this area of the plot.

VII. This area in the southeastern portion of the plot supports mature white spruce. Several of the oldest tree ages recorded (360, 328, 326, 267 and 254 years) are located here. Detritus comprises a smaller percentage of the ground cover in this area than in areas with younger trees. Lichens and mosses constitute the dominant ground cover. Bearberry, lingonberry, crowberry, dryas and Labrador tea are important in the area; anemone also occurs here.

VIII. This area, situated in the southwest corner of the plot, is comprised of younger trees (average age 99 years) and of smaller average circumference (16 cm). The number of trees per 10-$m^2$ quadrat averages 12. This is a moist area with lichens being the dominant ground cover. Pockets of sedges, horsetail and bearberry are common; anemone and wintergreen (*Pyrola grandiflora*) are scattered throughout the area.

## 4.3 Results of Vegetation Studies

### 4.3.1 Effects of Seismic Activity on Vegetation

The density of trees and shrubs or the number of individuals per ha is compared for seismic lines and undisturbed adjacent open spruce-lichen forest in Fig. 21. This graph shows that the undisturbed control lines have a greater shrub and tree density than do the seismic lines with the exception of seismic line 7 whose larger density can be accounted for by two reasons: an abundance of willow sprouts on the seismic line and the fact that the forest line borders a pond for a section of its length

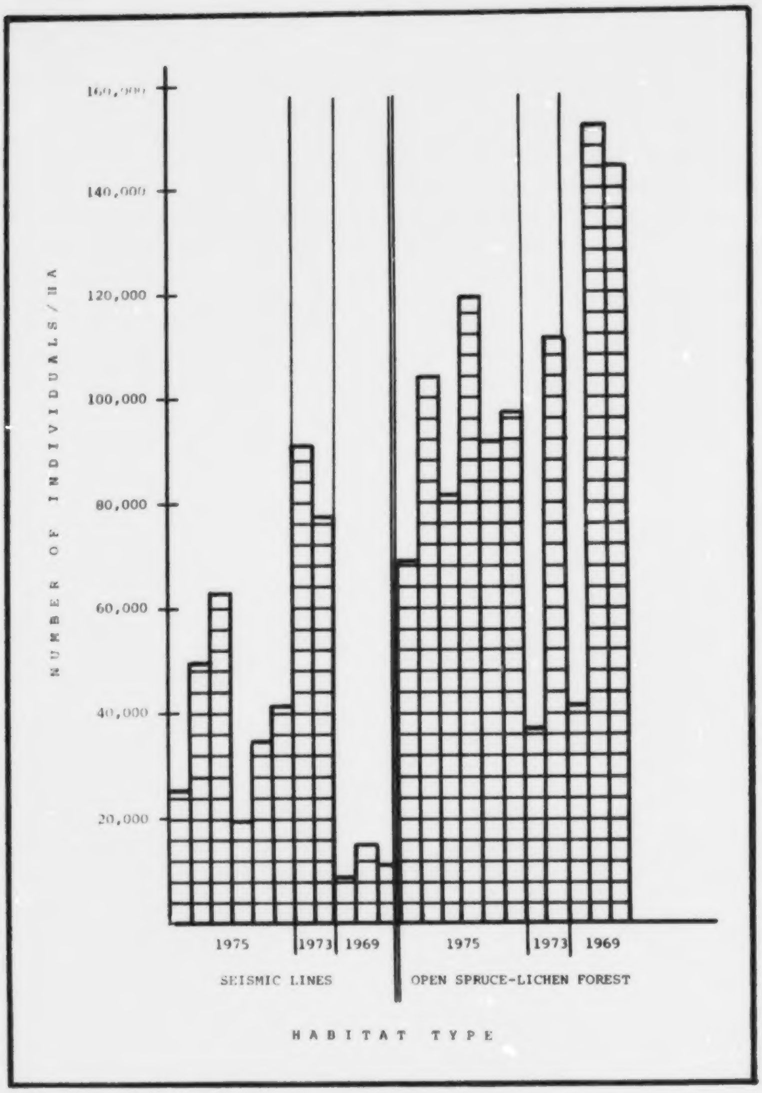

Fig. 21. Density of trees and shrubs on various-age seismic lines and in adjacent open spruce-lichen forest.

which decreases the measurement of trees and shrubs along its entire length.

Average importance values of the point-quarter sampling technique (Table 1), tabulated separately for the different years on both seismic and open spruce-lichen forest lines, show that blueberry is the most important species on the more recently cut seismic lines and also on the forest lines. Labrador tea is also an important plant species in the open spruce-lichen forest. Willows are important members of all transects, with by far the greatest regrowth on the seven year-old (1969-cut) seismic lines. Willow and blueberry both have the ability to sprout new shoots soon after cutting. White spruce is especially low in importance on older seismic lines because of the difficulty the seedlings have in becoming established on the eroded lines.

Percent cover of the different strata both on and off the seismic lines is compared between the north and south ends of Aubry Lake (Fig. 22). The tree and shrub stratum cover is from 20 to 40% greater at the south end on and off the seismic lines than at the north end. The tree and shrub stratum cover at the north end is approximately equal both on and off the seismic lines because the shrubs, which comprise the greatest cover percentage of this stratum, were not damaged by the bulldozer blades. It is also obvious from this graph that the spruce-lichen forest is more open at the sampling sites at the north end than at the south end.

The cover of grasses and sedges is 15% greater on the south-end seismic lines than on the other areas sampled. These results confirm the findings of Rickard and Slaughter (1973) who determined that cotton grass tussocks succeed on the level regions of seismic lines in Alaska and that grasses, specifically *Calamagrostis canadensis*, naturally revegetate the sloping areas of these seismic lines. The Aubry Lake south-end lines show the greatest erosion on the sloping portions because of a greater tendency for the insulative layer to be removed in the cutting of the line on slopes than on the level portions; this gives the resultant appearance of thermokarst and drainage gulleys on the south-end lines.

Lichens are abundant in the open spruce-lichen forest areas and indicate least cover on the 1969 seismic lines. Lichens are well-noted for their slow recolonization of disturbed sites.

Detritus (earth, berm, litter, rocks) obviously has much greater cover values on the seismic lines.

### 4.3.2 Species Richness On and Off Seismic Lines

The average number of species per quadrat sampled in the different habitat types ranges from 17.91 in the pond and river margins to 6.67 in

## TABLE 1

### Importance values of the tree and shrub strata on seismic lines and adjacent open spruce-lichen forest

| Line number | *Picea glauca* | *Salix* spp. | *Betula glandulosa* | *Alnus crispa* ssp. *crispa* | *Larix laricina* | *Ribes triste* | *Potentilla fruticosa* | *Shepherdia canadensis* | *Ledum palustre* ssp. *decumbens* | *Ledum palustre* ssp. *groenlandicum* | *Rhododendron lapponicum* | *Vaccinium uliginosum* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seismic Lines | | | | | | | | | | | | |
| Winter 1974-75: | | | | | | | | | | | | |
| 1A | 26.93 | 112.80 | 24.11 | 0 | 0 | 0 | 55.08 | 0 | 0 | 28.47 | 34.44 | 168.17 |
| 2A | 13.75 | 101.63 | 91.34 | 0 | 0 | 0 | 46.28 | 0 | 0 | 36.59 | 22.51 | 121.02 |
| 3A | 13.23 | 102.03 | 91.76 | 0 | 0 | 0 | 94.32 | 0 | 0 | 0 | 41.74 | 96.93 |
| 4A | 0 | 94.00 | 13.25 | 8.25 | 0 | 13.25 | 8.50 | 0 | 33.75 | 173.50 | 54.75 | 98.00 |
| 5A | 21.16 | 96.84 | 29.68 | 0 | 0 | 0 | 48.52 | 8.06 | 50.89 | 40.38 | 15.51 | 107.89 |
| 6A | 79.65 | 111.52 | 46.28 | 15.95 | 0 | 0 | 56.23 | 0 | 13.70 | 42.59 | 78.43 | 85.13 |
| **Average** | 25.79 | 103.14 | 49.40 | 4.03 | 0 | 2.21 | 51.49 | 1.39 | 16.39 | 53.59 | 41.23 | 112.86 |
| Winter 1973-74: | | | | | | | | | | | | |
| 7A | 36.51 | 50.53 | 53.75 | 13.02 | 0 | 6.91 | 0 | 0 | 78.36 | 22.04 | 41.12 | 70.13 |
| 8A | 23.23 | 86.71 | 54.06 | 26.53 | 0 | 0 | 6.92 | 0 | 16.53 | 135.95 | 6.70 | 112.90 |
| **Average** | 29.87 | 68.62 | 53.91 | 20.18 | 0 | 3.46 | 3.46 | 0 | 47.45 | 79.00 | 23.91 | 91.52 |
| Winter 1968-69: | | | | | | | | | | | | |
| 9A | 23.26 | 118.95 | 41.02 | 9.84 | 0 | 24.26 | 2.97 | 0 | 26.51 | 102.48 | 15.76 | 85.72 |
| 10A | 0 | 257.46 | 64.98 | 0 | 0 | 0 | 7.61 | 0 | 0 | 38.28 | 0 | 65.94 |
| 11A | 0 | 265.51 | 7.00 | 0 | 0 | 7.00 | 29.62 | 0 | 0 | 14.00 | 0 | 41.62 |
| **Average** | 7.75 | 213.97 | 37.67 | 3.28 | 0 | 10.42 | 22.31 | 0 | 8.84 | 51.59 | 5.25 | 64.43 |
| Forest Lines | | | | | | | | | | | | |
| Winter 1974-75: | | | | | | | | | | | | |
| 1B | 52.47 | 75.16 | 41.84 | 0 | 0 | 0 | 21.25 | 0 | 9.20 | 102.47 | 61.78 | 100.56 |
| 2B | 44.11 | 99.15 | 46.22 | 0 | 0 | 0 | 44.34 | 0 | 35.59 | 16.46 | 24.17 | 129.97 |
| 3B | 48.50 | 84.75 | 39.75 | 0 | 0 | 0 | 57.00 | 0 | 0 | 16.50 | 61.00 | 132.50 |
| 4B | 38.00 | 85.25 | 21.75 | 0 | 0 | 0 | 14.50 | 0 | 13.50 | 156.75 | 8.50 | 94.50 |
| 5B | 30.50 | 89.25 | 84.50 | 0 | 0 | 0 | 30.00 | 0 | 54.00 | 37.00 | 59.00 | 49.75 |
| 6B | 72.42 | 50.85 | 18.70 | 21.92 | 0 | 0 | 7.53 | 0 | 30.89 | 24.09 | 78.10 | 130.46 |
| **Average** | 47.67 | 80.74 | 42.13 | 3.65 | 0 | 0 | 29.10 | 0 | 23.86 | 58.88 | 48.76 | 106.29 |
| Winter 1973-74: | | | | | | | | | | | | |
| 7B | 42.83 | 102.02 | 104.53 | 7.56 | 0 | 0 | 21.79 | 0 | 63.81 | 43.54 | 48.75 | 46.75 |
| 8B | 54.55 | 31.66 | 29.02 | 0 | 0 | 0 | 0 | 0 | 63.79 | 124.51 | 30.96 | 102.40 |
| **Average** | 48.69 | 66.84 | 66.78 | 3.78 | 0 | 0 | 10.90 | 0 | 63.80 | 84.03 | 39.86 | 74.55 |
| Winter 1968-69 | | | | | | | | | | | | |
| 9B | 169.01 | 90.39 | 23.83 | 0 | 10.13 | 0 | 32.75 | 0 | 0 | 157.18 | 56.41 | 40.43 |
| 10B | 34.69 | 102.15 | 92.11 | 0 | 6.76 | 0 | 7.02 | 0 | 32.20 | 66.90 | 16.10 | 73.37 |
| 11B | 19.64 | 72.88 | 62.75 | 0 | 0 | 0 | 15.89 | 0 | 31.96 | 131.82 | 6.82 | 88.21 |
| **Average** | 74.45 | 88.47 | 59.56 | 0 | 5.63 | 0 | 18.55 | 0 | 21.39 | 118.63 | 26.44 | 67.34 |

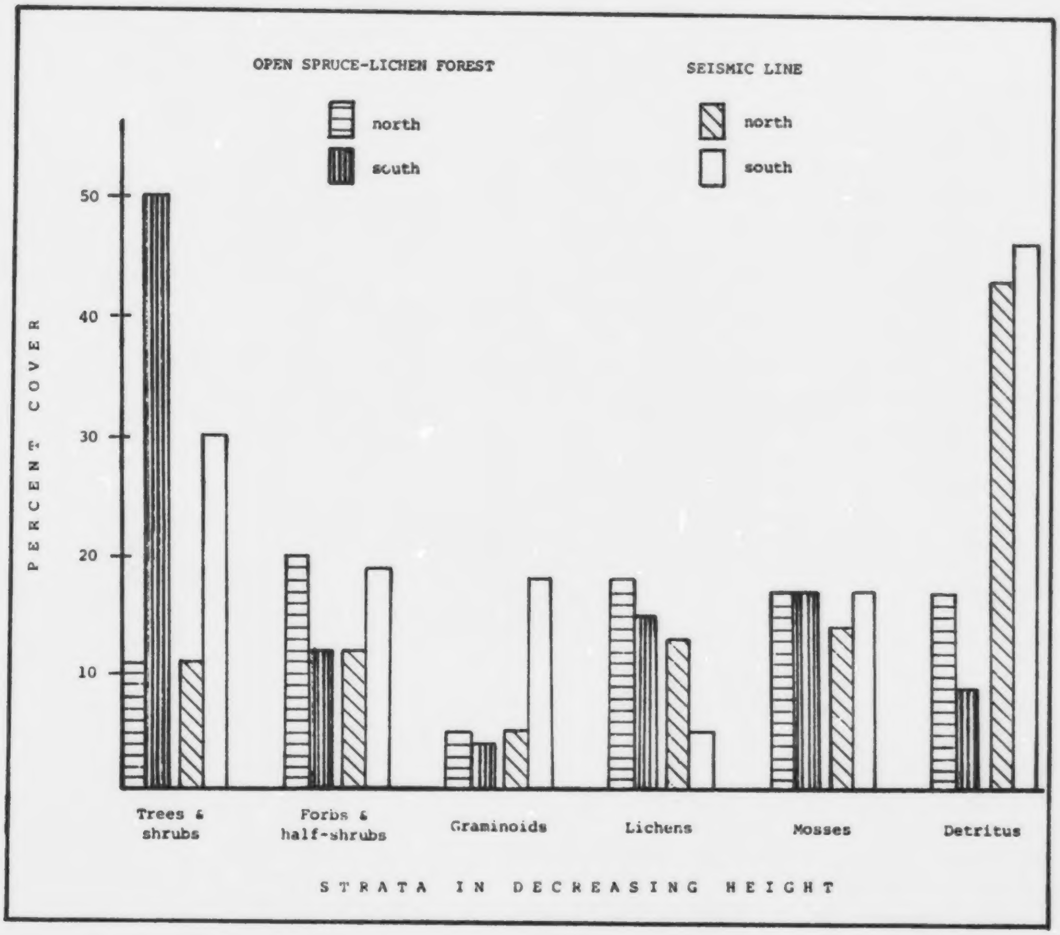

Fig. 22. Comparison of percent cover of various strata of vegetation in the open spruce-lichen forest and on seismic lines at the north and south ends of Aubry Lake.

the lichen heaths (Fig. 23). In pond and river margins, open spruce-lichen forest species are found as well as those specific to the margins and hence the greatest number of species in this habitat type. Seismic lines (17.36 species/quadrat) possess only slightly fewer species per quadrat than pond and river margins and only slightly more than open spruce-lichen forests.

### 4.3.3 Thermokarst and Erosional Subsidence along Seismic Lines

The average subsidence of the seismic lines along the six traplines (9 through 14) at the south end of Aubry Lake ranges from 26.4 to 43.5 cm and averages 34.2 cm below the adjacent undisturbed ground surface. The disturbed portion of the seismic lines, including the berms, ranges from 9.0 to 13.2 m and averages 11.1 m in width.

The traverse lines taken over the supply trails at the south end of Aubry Lake are reproduced in Fig. 24 in order to illustrate the extreme variation and extent of slumping in these track ruts; some show negligible slump while others are gullies up to 182 cm below the adjacent undisturbed ground. Average slump on the trails is 81 cm.

## 4.4 Results of Small Mammal Studies

### 4.4.1 Small Mammal Populations

The various live and kill trapping programmes conducted during the summers of 1976 and 1977 produced a total of 932 specimens. The red-backed vole is the most abundant small mammal, representing 86.8% of the total catch. The other small mammals captured are rare by comparison: meadow voles comprise only 4.8% of the total take, chestnut-cheeked voles comprise 4.2%, masked shrews 2.4% and brown lemmings 1.8%.

The relative abundance of these small mammals throughout the area would have been difficult to ascertain without trapping due to the confusing nature of the rodent sign. There were numerous areas with freshly abandoned runways and burrow systems and other areas with numerous animals which lacked obvious sign. The sites with relatively fresh and abundant sign but no animals had obviously had their local rodent populations only recently extirpated, while those sites which had animals but no abundant sign had obviously been only recently colonized.

The data from the removal trapping programme (standard traplines and exploratory traplines) point out another factor that influences the abundance of small mammals. In 20,664 TN, 833 small mammals were captured (4.03 mammals/100 TN); for the most part, these small mammals

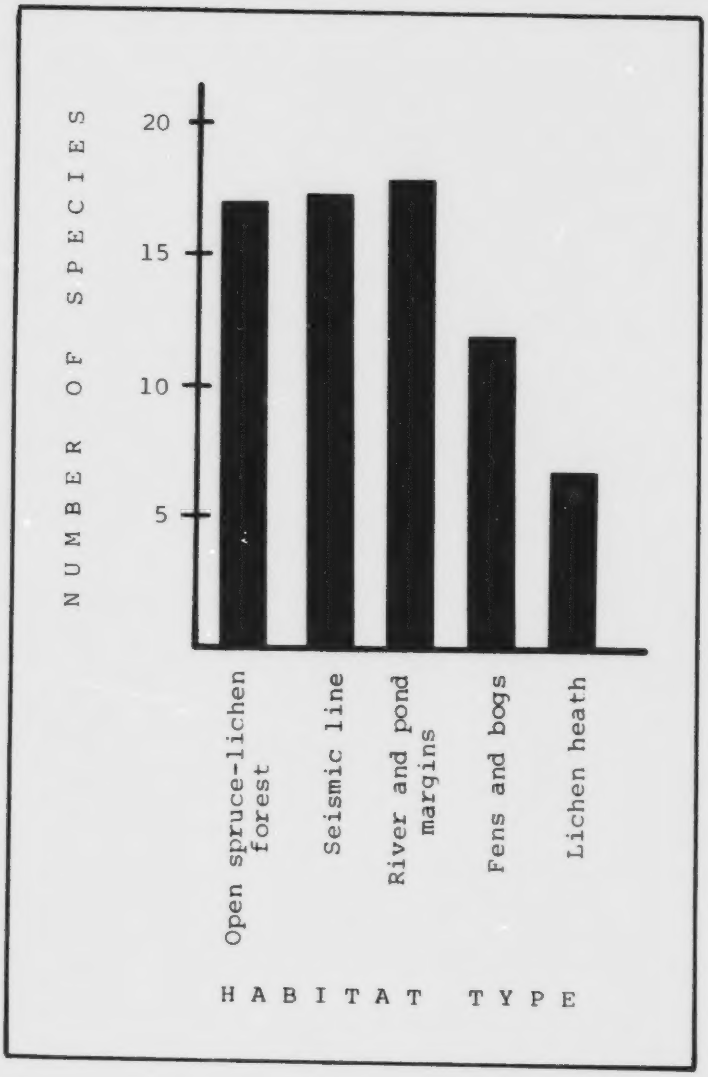

Fig. 23. Average number of plant species per quadrat in various habitats and on seismic lines.

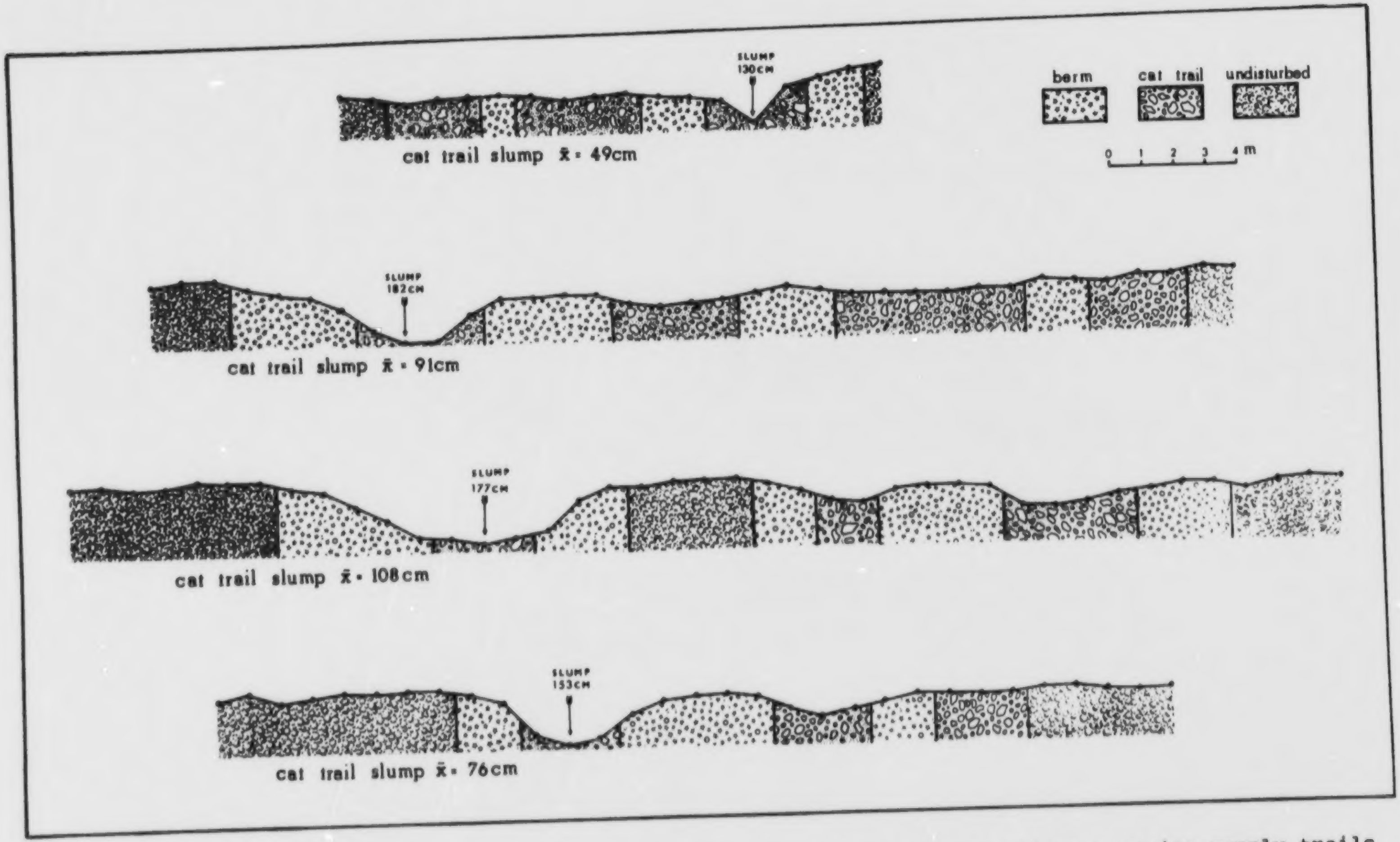
SLUMP 130CM
berm
cat trail
undisturbed
0 1 2 3 4 m
cat trail slump x̄ = 49cm
SLUMP 182CM
cat trail slump x̄ = 91cm
SLUMP 177CM
cat trail slump x̄ = 108cm
SLUMP 153CM
cat trail slump x̄ = 76cm

Fig. 24. Thermokarst subsidence measurements taken along four traverse lines crossing supply trails leading to the Mobile-Colville E-15 drill site (see Fig. 4). The vertical scale is identical to the horizontal scale. Average slump on these four trails is 81 cm below the undisturbed ground level.

were removed from localized pockets, while few were taken from vast areas of similar habitat between these pockets.

Only two localities were encountered with comparatively dense small mammal populations. One area was situated northwest of the north arm of Aubry Lake in open spruce-lichen forest and around the shorelines of two nearby thermokarst ponds. Part of this area was established as the live-trapping plot. In fact, the plot was established in this locale because it was the only site at the north end of the lake which appeared to warrant a mark-recapture study. Prior to the establishment of the plot, 40 small mammals were captured in 494 TN (8.10 mammals/100 TN) with exploratory traplines 4, 6 and 7 (Table 2). An additional 57 animals were taken in 840 TN (6.79 mammals/100 TN) on standard traplines 2B and 3B (Table 3) in the same vicinity. The trapping data in Tables 3 and 4 indicate that small mammal populations in this area increased three-fold between 1976 and 1977 (from 4.05 mammals/100 TN to 12.61 mammals/100 TN).

The only other area of relatively high small mammal density was encountered at the south end of Aubry Lake in the spruce-lichen forest surrounding standard trapline 13B. On this control line 31 small mammals were captured in 420 TN (7.38 mammals/100 TN) in 1976.

Two exploratory traplines (2 and 3) and two standard traplines (4A and 7A) did not produce any small mammals. Excluding the above-mentioned areas of relatively high density or no density, the remainder of the exploratory and standard traplines yielded from 0.24 to 9.28 mammals/100 TN.

### 4.4.2 Vole Food Preference Tests

Red-backed voles showed a marked preference toward fruit and flowers of the vascular plants offered and avoided most of the stems, leaves and roots in the cafeteria feeding trials (Table 5). The only two plants which were entirely and eagerly consumed by the red-backed voles were yellow cress (*Rorippa islandica*) and northern water carpet (*Chrysosplenium tetrandrum*); both plants occupy moist habitats (see Appendix 6.1). In fact, most of the plants bearing fruits and seeds for which the red-backed voles showed a strong preference including sedges, rushes, grasses, brambles (*Rubus* spp.), false asphodel (*Tofieldia* sp.), crowfoot (*Ranunculus confervoides*) and fleabane (*Erigeron elatus*) all thrive along the shorelines or in other moist habitats. The only plant commonly occupying the drier spruce-lichen forest which was readily eaten by the red-backed voles was alpine blueberry (*Vaccinium uliginosum*). Of the 90 species of vascular plants offered to these voles, 20 were entirely rejected.

The mushroom *Lycoperdon*, the only non-vascular plant eaten by the red-backed voles, was consumed by six of the eight test animals. Studies elsewhere in North America and Eurasia point out the use of non-vascular

## TABLE 2

Results of exploratory traplines set at the north end of Aubry Lake in 1976

| Line number and description | Date | TN | Catch* A | Catch* B | Catch* C | Catch* D | Catch* E | Mammals/100 TN |
|---|---|---|---|---|---|---|---|---|
| 1. Along shoreline of Aubry Lake in area dominated by willows and alders | 8-15 June | 336 | 1 | 0 | 0 | 0 | 0 | 0.30 |
| 2. On top of esker in old spruce-lichen burn, set among shrub birch and blueberry | 8-14 June | 394 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3. Along small creek draining into Aubry Lake, set among willows and sedges | 14-18 June | 60 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4. In *Sphagnum* bog with dense cover of shrub birch and scattered white spruce | 16-24 June | 239 | 4 | 0 | 4 | 4 | 1 | 5.43 |
| 5. In small bog | 18-21 June | 60 | 1 | 0 | 0 | 0 | 0 | 1.67 |
| 6. Along shoreline of thermokarst pond | 18-21 June | 105 | 6 | 5 | 0 | 0 | 0 | 10.48 |
| 7. Along shoreline of thermokarst pond | 18-21 June | 150 | 3 | 0 | 13 | 0 | 0 | 10.67 |
| Total | | 1,344 | 15 | 5 | 17 | 4 | 1 | 3.13 (average) |

*Catch: A = red-backed vole, B = meadow vole, C = chestnut-cheeked vole, D = brown lemming, E = masked shrew

## TABLE 3

Summary of small mammal kill trapping on and off seismic lines at Aubry Lake in summer 1976

| | Catch* from traplines on seismic lines | | | | | Catch* from control traplines parallel to seismic lines | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | A | B | C | D | E |
| Seismic lines cut winter 1974-75 (5,040 TN) | | | | | | | | | | |
| Line 1 | 1 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 |
| Line 2 | 2 | 0 | 1** | 0 | 0 | 16 | 0 | 2 | 2 | 0 |
| Line 3 | 3 | 2** | 0 | 0 | 1** | 33 | 0 | 0 | 4 | 0 |
| Line 4 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 |
| Line 5 | 11 | 2** | 0 | 0 | 0 | 26 | 0 | 0 | 0 | 2 |
| Line 6 | 6 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| Subtotal | 23 | 4 | 1 | 0 | 1 | 92 | 0 | 2 | 6 | 2 |
| | 1.15 mammals/100 TN | | | | | 4.05 mammals/100 TN | | | | |
| Seismic lines cut winter 1973-74 (1,680 TN) | | | | | | | | | | |
| Line 7 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| Line 8 | 1 | 0 | 0 | 0 | 0 | 7 | 0 | 1 | 0 | 0 |
| Subtotal | 1 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 |
| | 0.12 mammals/100 TN | | | | | 1.19 mammals/100 TN | | | | |
| Seismic lines cut winter 1968-69 (5,040 TN) | | | | | | | | | | |
| Line 9 | 0 | 3 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 |
| Line 10 | 3 | 3 | 0 | 0 | 1 | 12 | 0 | 0 | 0 | 1 |
| Line 11 | 6 | 11 | 0 | 0 | 2 | 17 | 1 | 0 | 0 | 1 |
| Line 12 | 3 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 1 |
| Line 13 | 1 | 0 | 0 | 0 | 0 | 28 | 0 | 0 | 0 | 3 |
| Line 14 | 3 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 |
| Subtotal | 16 | 17 | 0 | 0 | 3 | 83 | 1 | 0 | 0 | 6 |
| | 1.43 mammals/100 TN | | | | | 3.57 mammals/100 TN | | | | |
| Total catch for all traplines (11,760 TN) | | | | | | | | | | |
| | 40 | 21 | 1 | 0 | 4 | 184 | 1 | 3 | 6 | 8 |
| | 1.12 mammals/100 TN | | | | | 3.44 mammals/100 TN | | | | |

*Catch: A = red-backed vole, B = meadow vole, C = chestnut-cheeked vole, D = brown lemming, E = masked shrew

**Specimens captured on seismic lines but in undisturbed bogs or pond margins

## TABLE 4

Summary of small mammal kill trapping on and off seismic lines at Aubry Lake in summer 1977

| | Catch* from traplines on seismic lines | | | | | Catch* from control traplines parallel to seismic lines | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | A | B | C | D | E |
| Seismic lines cut winter 1974-75 (5,040 TN) | | | | | | | | | | |
| Line 1 | 3 | 0 | 0 | 0 | 0 | 35 | 1 | 0 | 0 | 1 |
| Line 2 | 14 | 0 | 0 | 0 | 0 | 56 | 0 | 9 | 1 | 0 |
| Line 3 | 23 | 0 | 3 | 1 | 2 | 52 | 0 | 1 | 2 | 0 |
| Line 4 | 14 | 2 | 0 | 0 | 0 | 55 | 0 | 0 | 0 | 0 |
| Line 5 | 12 | 0 | 2 | 0 | 0 | 69 | 5 | 1 | 1 | 1 |
| Line 6 | 9 | 0 | 0 | 0 | 1 | 27 | 0 | 0 | 0 | 1 |
| Subtotal | 75 | 2 | 5 | 1 | 3 | 294 | 6 | 11 | 4 | 3 |
| | 3.41 mammals/100 TN | | | | | 12.61 mammals/100 TN | | | | |
| Seismic lines cut winter 1968-69 (2,520 TN) | | | | | | | | | | |
| Line 9 | 0 | 1 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 |
| Line 10 | 7 | 2 | 0 | 0 | 1 | 39 | 0 | 0 | 0 | 0 |
| Line 11 | 9 | 6 | 0 | 0 | 0 | 32 | 0 | 0 | 0 | 0 |
| Subtotal | 16 | 9 | 0 | 0 | 1 | 93 | 0 | 0 | 0 | 0 |
| | 2.06 mammals/100 TN | | | | | 7.38 mammals/100 TN | | | | |
| Total catch for all traplines (7,560 TN) | 91 | 11 | 5 | 1 | 4 | 387 | 6 | 11 | 4 | 3 |
| | 2.96 mammals/100 TN | | | | | 10.87 mammals/100 TN | | | | |

*Catch: A = red-backed vole, B = meadow vole, C = chestnut-cheeked vole, D = brown lemming, E = masked shrew

## TABLE 5

Vole food preferences as determined by cafeteria feeding trials

| Plant species offered | Red-backed vole | | | | | Chestnut-cheeked vole | | | | | Meadow vole | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | L | Fr | Fl | R* | S | L | Fr | Fl | R | S | L | Fr | Fl | R |
| Fungi | | | | | | | | | | | | | | | |
| *Lycoperdon* sp. | 2[+] | | | | | 0 | | | | | | | | | |
| Lichens | | | | | | | | | | | | | | | |
| *Peltigera apthosa* | 0 | | | | | 0 | | | | | | | | | |
| *Cladina alpestris* | 0 | | | | | 0 | | | | | | | | | |
| Musci | | | | | | | | | | | | | | | |
| *Sphagnum* sp. | 0 | | | | | 1 | | | | | | | | | |
| *Aulacomnium* sp. | | | | | | 0 | | | | | | | | | |
| *Catoscopium nigritum* | 0 | | | | | 0 | | | | | | | | | |
| *Abietinella abietina* | | | | | | 0 | | | | | | | | | |
| Hepaticae | | | | | | | | | | | | | | | |
| *Marchantia polymorpha* | | | | | | 0 | | | | | 0 | | | | |
| Vasculares | | | | | | | | | | | | | | | |
| *Lycopodium annotium* | 0 | 0 | 0 | | | 1 | 1 | 1 | | | | | | | |
| *Equisetum variegatum* | 1 | | | | | | | | | | | | | | |
| *E. scirpoides* | 0 | | | | | 1 | | | | | | | | | |
| *E. fluviatile* | 2 | | | | | 3 | | | | | | | | | |
| *E. silvaticum* | 1 | | | | | 3 | | | | | | | | | |
| *E. arvense* | 2 | | | | | 3 | | | | | | | | | |

. . . continued

TABLE 5 (CONTINUED)

| Plant species offered | Red-backed vole | | | | | Chestnut-cheeked vole | | | | | Meadow vole | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | L | Fr | Fl | R* | S | L | Fr | Fl | R | S | L | Fr | Fl | R |
| Vasculares (continued) | | | | | | | | | | | | | | | |
| *Picea glauca* | $0^+$ | 0 | | | | 0 | 0 | 0 | | | | | | | |
| *Juniperus communis* | 0 | 0 | 1 | | | 0 | 0 | 0 | | | | | | | |
| *Sparganium angustifolium* | 1 | 1 | 2 | | | 3 | 3 | 3 | | | | | | | |
| *Potamogeton praelongus* | 1 | 1 | 0 | | | 0 | 0 | 0 | | | | | | | |
| *P. perfoliatus* | 1 | 1 | 0 | | | 0 | 0 | 3 | | | | | | | |
| *P. Berchtoldi* | 1 | 1 | 2 | | | 0 | 0 | 0 | | | | | | | |
| *P. filiformis* | 0 | 0 | 2 | | | 0 | 0 | 3 | | | | | | | |
| *Arctagrostis latifolia* | | | | | | 2 | 3 | 3 | | | 1 | 3 | 3 | | |
| *Calamagrostis canadensis* | 0 | 0 | 1 | | | 3 | 3 | 3 | | | | | | | |
| *C. neglecta* | | | | | | 3 | 2 | 3 | | | 3 | 3 | 3 | | |
| *C. purpurascens* | 1 | 1 | 1 | | | 2 | 3 | 2 | | | 3 | 3 | 3 | | |
| *Poa alpigens* | 0 | 0 | 1 | | | 3 | 3 | 3 | | | | | | | |
| *P. lanata* | 1 | 0 | 3 | | | 3 | 3 | 3 | | | | | | | |
| *Arctophila fulva* | 0 | 0 | 1 | | | 3 | 3 | 3 | | | | | | | |
| *Eriophorum Scheuchzeri* | 1 | 0 | 1 | | 0 | 3 | 3 | 3 | | 3 | | | | | |
| *E. brachyantherum* | | | | | | 3 | 3 | 3 | | | | | | | |
| *Trichophorum caespitosum* | 0 | 0 | 1 | | 0 | | | | | | | | | | |
| *Eleocharis acicularis* | 2 | | 2 | | 0 | 3 | | 3 | | 0 | | | | | |
| *Carex capitata* | 1 | 1 | 2 | | | | | | | | | | | | |
| *C. aquatilis* | 1 | 1 | 2 | | | 3 | 3 | 3 | | | | | | | |
| *C. limosa* | 1 | 1 | 3 | | | 3 | 3 | 3 | | | 3 | | 3 | | |
| *C. capillaris* | 0 | 0 | 1 | | | 3 | 3 | 3 | | | | | | | |
| *C. membranacea* | 0 | 0 | 1 | | | 3 | 3 | 3 | | | | | | | |
| *Juncus arcticus* | 1 | 0 | 3 | | | 2 | | 3 | | | 3 | | 3 | | |

. . . continued

TABLE 5 (CONTINUED)

| Plant species offered | Red-backed vole |  |  |  |  | Chestnut-cheeked vole |  |  |  |  | Meadow vole |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | S | L | Fr | Fl | R* | S | L | Fr | Fl | R | S | L | Fr | Fl | R |
| Vasculares (continued) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| *Juncus castaneus* | $1^+$ | 0 | 3 |  | 0 | 3 | 3 | 3 |  | 0 |  |  |  |  |  |
| *J. alpinus* | 1 | 0 | 3 |  | 0 | 3 | 3 | 3 |  | 3 |  |  |  |  |  |
| *Tofieldia pusilla* | 0 | 0 | 3 |  | 0 | 1 | 0 | 2 |  | 0 | 3 | 0 | 3 |  |  |
| *Zygadenus elegans* | 0 | 0 | 2 |  |  | 1 | 2 | 0 |  |  |  |  |  |  |  |
| *Populus balsamifera* | 0 | 0 |  |  |  | 0 | 3 |  |  |  |  |  |  |  |  |
| *Salix reticulata* | 0 | 0 | 1 |  |  | 1 | 2 | 2 |  |  |  |  |  |  |  |
| *S. glauca* | 0 | 1 | 1 |  |  | 1 | 3 | 2 |  |  |  |  |  |  |  |
| *S. myrtillifolia* |  |  |  |  |  | 2 | 2 |  |  | 1 | 0 | 1 |  |  |  |
| *S. lanata* | 0 | 0 |  |  |  | 0 | 1 |  |  |  |  |  |  |  |  |
| *S. alaxensis* |  |  |  |  |  | 2 | 3 | 2 |  |  |  |  |  |  |  |
| *S. arbusculoides* | 0 | 1 | 0 |  |  | 1 | 2 |  |  |  |  |  |  |  |  |
| *Myrica gale* | 0 | 0 | 0 |  |  | 0 | 0 | 0 |  |  | 1 | 0 | 1 |  |  |
| *Betula glandulosa* | 0 | 0 | 0 |  |  | 0 | 0 | 0 |  |  |  |  |  |  |  |
| *Alnus crispa* | 0 | 0 | 0 |  |  | 1 | 1 | 0 |  |  |  |  |  |  |  |
| *Geocaulon lividum* | 0 | 0 | 2 |  |  | 0 | 0 | 0 |  |  |  |  |  |  |  |
| *Stellaria crassifolia* | 1 | 1 | 2 |  |  | 1 | 1 |  |  |  |  |  |  |  |  |
| *Minuartia dawsonensis* | 0 | 0 | 0 |  |  | 3 | 3 | 3 |  |  |  |  |  |  |  |
| *Nuphar variegatum* | 1 | 1 | 1 |  |  | 0 | 1 | 0 |  |  |  |  |  |  |  |
| *Anemone parviflora* | 0 | 1 |  | 2 |  | 3 | 3 |  | 2 |  |  |  |  |  |  |
| *Pulsatilla patens* | 0 | 0 |  |  |  | 3 | 3 |  |  |  |  |  |  |  |  |
| *Rununculus confervoides* | 0 | 0 | 3 | 3 |  | 0 | 0 | 0 | 0 |  |  |  |  |  |  |
| *R. reptans* | 2 |  |  | 2 |  | 3 | 3 |  | 3 |  | 3 | 3 |  | 3 |  |
| *Rorippa islandica* | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |  |  |  |  |  |
| *Chrysosplenium tetrandrum* | 2 | 2 | 2 |  |  | 3 | 3 | 3 |  |  |  |  |  |  |  |

. . . continued

TABLE 5 (CONTINUED)

| Plant species offered | Red-backed vole | | | | | Chestnut-cheeked vole | | | | | Meadow vole | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | L | Fr | Fl | R* | S | L | Fr | Fl | R | S | L | Fr | Fl | R |
| Vasculares (continued) | | | | | | | | | | | | | | | |
| *Parnassia palustris* | $0^+$ | 0 | 2 | 2 | 0 | 2 | 2 | 3 | 3 | 2 | | | | | |
| *Ribes hudsonianum* | | | | | | 1 | 0 | 2 | | | 1 | 3 | 2 | | |
| *R. triste* | 0 | 0 | 1 | | | 0 | 0 | 0 | | | | | | | |
| *Rubus chamaemorus* | 0 | 0 | 3 | | | 2 | 2 | 2 | | | 0 | 0 | 3 | | |
| *R. arcticus* | 0 | 0 | 2 | 0 | | | | | | | | | | | |
| *Potentilla palustris* | 1 | 1 | 2 | | | 2 | 2 | 2 | | | | | | | |
| *P. fruticosa* | 0 | 0 | 1 | | | 0 | 0 | 0 | | | | | | | |
| *P. norvegica* | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | | 3 | | | | | |
| *Dryas integrifolia* | 0 | 0 | 1 | | | 0 | 0 | | 3 | | 1 | 1 | | | |
| *Rosa acicularis* | 0 | 0 | 2 | | | 0 | 0 | 3 | | | | | | | |
| *Oxytropis campestris* | 1 | 2 | 3 | | | 1 | 1 | 0 | | 1 | 3 | 3 | 3 | | 2 |
| *Hedysarum alpinum* | 0 | 1 | 2 | | | 3 | 3 | 3 | | | | | | | |
| *Shepherdia canadensis* | 0 | 0 | 1 | | | 1 | 1 | 2 | | | | | | | |
| *Epilobium angustifolium* | 0 | 0 | 1 | | | 1 | 1 | | 1 | | | | | | |
| *E. latifolium* | 0 | 0 | 1 | 1 | | 1 | 1 | 0 | 0 | | 1 | 0 | 1 | 0 | |
| *E. davuricum* | 0 | 0 | 0 | | | 2 | 2 | | 2 | | 1 | 1 | | 3 | |
| *Myriophyllum spicatum* | 0 | 0 | 2 | | | 0 | 0 | 3 | | | | | | | |
| *Hippuris vulgaris* | 1 | 1 | | | | 2 | 2 | | | | | | | | |
| *Pyrola asarifolia* | 0 | 0 | 0 | | 0 | 0 | 1 | 0 | | 0 | | | | | |
| *P. grandiflora* | 0 | 0 | | | 0 | 2 | 2 | | | | | | | | |
| *P. secunda* | 0 | 0 | 0 | | 0 | 0 | 1 | 0 | | 0 | | | | | |
| *Empetrum nigrum* | 0 | 0 | 2 | | | 0 | 0 | 2 | | | | | | | |
| *Ledum palustre decumbens* | 0 | 0 | | | | 1 | 1 | | | | | | | | |
| *L. palustre groenlandicum* | 0 | 0 | 0 | | | 0 | 0 | 2 | | | | | | | |

. . . continued

TABLE 5 (CONTINUED)

| | Red-backed vole | | | | | Chestnut-cheeked vole | | | | | Meadow vole | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | L | Fr | Fl | R[*] | S | L | Fr | Fl | R | S | L | Fr | Fl | R |
| Vasculares (continued) | | | | | | | | | | | | | | | |
| *Rhododendron lapponicum* | 0[+] | 0 | | | | 0 | 0 | | | | | | | | |
| *Cassiope tetragona* | 0 | 0 | | | | 1 | 0 | 1 | | | | | | | |
| *Andromeda polifolia* | 0 | 0 | 2 | | | 2 | 3 | 3 | | | 1 | 2 | 0 | | |
| *Chamaedaphne calyculata* | 0 | 0 | 1 | | | 1 | 0 | 0 | | | | | | | |
| *Arctostaphylos uva-ursi* | 0 | 0 | 2 | | | 1 | 1 | 3 | | | 0 | 0 | 0 | | |
| *A. rubra* | 1 | 0 | 2 | | | 1 | 0 | 2 | | | | | | | |
| *Vaccinium vitis-idaea* | 0 | 0 | 1 | | | 0 | 3 | 3 | | | | | | | |
| *V. uliginosum* | 0 | 0 | 3 | | | 1 | 0 | 2 | | | | | | | |
| *Oxycoccus microcarpus* | 0 | 0 | 2 | | | 2 | 2 | 2 | | | | | | | |
| *Gentiana propinqua* | 2 | 1 | | 2 | | 2 | 2 | | 3 | | 3 | 3 | | 3 | |
| *Pedicularis labradorica* | 1 | 1 | 1 | 1 | | 3 | 3 | 3 | | | 3 | 3 | 3 | | |
| *Boschniakia rossica* | 0 | 0 | 0 | | 0 | 1 | 1 | 1 | | 1 | | | | | |
| *Utricularia vulgaris* | | | | | | 1 | 1 | | 3 | | 3 | 3 | | 3 | |
| *Erigeron elatus* | 0 | 0 | 3 | | 0 | 3 | 3 | 3 | | 3 | | | | | |
| *Artemisia Tilesii* | 0 | 0 | | 1 | | 0 | 0 | | 0 | | | | | | |
| *Petasites frigidus* | | 1 | | | | | 2 | | | | | | | | |
| *Senecio congestus* | 0 | 0 | 2 | 0 | | 3 | 3 | 3 | 3 | | | | | | |
| *S. lugens* | 1 | 1 | 2 | 1 | | 1 | 1 | 1 | 1 | | 2 | 2 | 1 | 3 | |
| *Saussurea angustifolia* | 1 | 1 | 2 | | | 3 | 3 | 3 | | | | | | | |
| Total number of species offered | 94 | 83 | 71 | 12 | 14 | 100 | 87 | 70 | 14 | 14 | 22 | 19 | 15 | 6 | 1 |

[*] Plant part code: S = stem or thalli, L = leaf, Fr = fruit, Fl = flower, R = root

[+] Preference value code: 0 = rejected by all voles, 1 = accepted very poorly by some and rejected by others, 2 = acceptance variable; some rejected while others readily consumed, 3 = eagerly consumed by most voles plants in the diets of northern microtine rodents (Banfield, 1974a; Koshkina, 1957, 1961; Llano, 1956; Nasimovich *et al.*, 1948; Riewe, 1973; Shtil'mark, 1965; Vorontsev, 1961; Youngman, 1975).

Douglass (1974) examined the food habits of *Clethrionomys rutilus* from Chick Lake, N.W.T. by analyzing the stomach contents of voles captured in May and September. He found that the spring diet of the red-backed voles consists primarily of an unidentified fungus (76.68%) and horsetail (*Equisetum*) (14.44%); the other items which occurred in the samples much less frequently include the lichens *Cladonia* and *Cetraria*, Labrador tea (*Ledum*), arthropods, mosses and *Vaccinium*. In the autumn the bulk of the stomach contents was still the unidentified fungus (79.10%). There was, however, a shift in the ranking of the other items in the voles' diets, with an increased use of willow herb (*Epilobium*), grasses, seeds, mosses and insects.

Dyke (1971) reported that red-backed voles from Heart Lake, N.W.T. consume large quantities of chlorophylous materials, lichens and over-wintered seeds in the spring and various berries in the fall. They likewise depend heavily on mushrooms but do not feed on insects.

In my feeding trials, the chestnut-cheeked voles displayed a much broader feeding spectrum than did the red-backed voles. Unlike the red-backed voles, the chestnut-cheeked voles accepted stems and leaves as readily as they accepted fruit and flowers (Table 5). A large assortment of grasses, sedges, rushes, several aquatic species including horsetail (*Equisetum fluviatile*), burreed (*Sparganium* sp.), pondweeds (*Potamogeton* spp.), water milfoil (*Myriophyllum* sp.), mare's tail (*Hippuris* sp.) and bladderwort (*Utricularia* sp.) and numerous other species which occupy moist habitats were readily consumed by the chestnut-cheeked voles. Several plants which were entirely rejected or only poorly accepted by the red-backed voles were readily consumed by the chestnut-cheeked voles; the more-notable of these species are the grasses *Poa alpigens* and *Arctophila fulva*, the sedges *Carex capillaris* and *C. membranacea*, balsam poplar (*Populus* sp.), willow (*Salix glauca*), sandwort (*Minuartia* sp.), pasqueflower (*Pulsatilla* sp.), cinquefoil (*Potentilla norvegica*), *Dryas* sp., lingonberry (*Vaccinium vitis-idaea*) and lousewort (*Pedicularis labradorica*). The chestnut-cheeked voles, in fact, rejected only 10 of the 93 vascular plants offered to them in the feeding tests. The only non-vascular plant accepted by the chestnut-cheeked voles was *Sphagnum* moss, and it was only nibbled.

Very little has previously been recorded about the food habits of the rare and elusive microtine *Microtus xanthognatus*. While trapping a colony of chestnut-cheeked voles near Old Crow in the Yukon, Youngman (1975) noted 13 plants which he assumed to be food for this vole. Seven of the species recorded by Youngman were also included in my feeding trials [*Sphagnum* sp., reed bent grass (*Calamagrostis canadensis*), cloudberry (*Rubus chamaemorus*), fireweed (*Epilobium angustifolium*), bearberry (*Arctostaphylos rubra*), lingonberry (*Vaccinium vitis-idaea*) and alpine blueberry (*V. uliginosum*)]; the remaining species were either not recorded in my study area [for example, the mushrooms *Lactarius aurantiacus*, *Russula turci* and *Hebloma sordidlilum*, high bush crarberry (*Viburnum edule*) and sweet coltsfoot (*Petasites hyperboreus*)] or not used in my feeding trials. Banfield (1974a) mentions only that chestnut-cheeked voles seem to feed a great deal on horsetails and lichens. The one stomach sample examined by Douglass (1974) contained primarily the remains of horsetails (*Equisetum*) and sedges (*Carex*).

In the Aubry Lake feeding tests, there were only four species of vascular plants which were completely rejected by both the red-backed and chestnut-cheeked voles. These include two of the dominant species in the region, white spruce (*Picea glauca*) and dwarf birch (*Betula glandulosa*), plus sweet gale (*Myrica gale*) and Lapland rosebay (*Rhododendron lapponicum*).

Unfortunately, I did not obtain comparable food preference data for meadow voles because too few species (22) were presented to only one individual. However, from the data available, it appears that the meadow voles possess even broader feeding habits than do their larger relatives, the chestnut-cheeked voles. It has been shown elsewhere that meadow voles are primarily grazers, feeding on the vegetative parts of grasses, sedges, rushes and forbs, although in the winter the bark of trees and shrubs is often consumed (Bailey, 1924; Linduska, 1942; Parker, 1941; Riewe, 1973; Thompson, 1965). Occasionally berries, nuts and seeds are also eaten (Riewe, 1973). A few studies have also noted that the genus *Microtus* has a propensity for meat (Riewe, 1973; Voge, 1950; Wellwood, 1956; Zimmerman, 1965).

It might be expected that the voles would occupy habitats with the greatest diversity of palatable plants, but this does not seem to be the situation, particularly for red-backed voles. The habitats which possess the largest number of palatable plants accepted by red-backed voles in the cafeteria feeding tests (food preference codes 2 and 3) include pond and river margins (34 species), shorelines (26 species) and disturbed sites (23 species). Red-backed voles, however, were caught far less frequently in these habitats than in the undisturbed open spruce-lichen forest which possesses only 19 palatable plant species. Thus, despite the fact that seismic lines can create habitat with a greater diversity of palatable plants for red-backed voles than do undisturbed spruce-lichen forests, the voles do not take advantage of these disturbed sites. Food availability is one of the most important factors affecting animal distribution, but in this situation where there are diverse food resources in several habitats, it is obviously not the limiting factor.

### 4.4.3 Vole Home Ranges

During the 21-day trapping period on the mark-recapture plot at the north end of Aubry Lake, 99 small mammals were captured a total of 933 times. The catch consists of 92 red-backed voles, 2 chestnut-cheeked voles, 2 masked shrews, 2 brown lemmings and 1 meadow vole. Home ranges were calculated for those small mammals which were captured at three or more trap stations not in a straight line; only some of the red-backed voles were captured a sufficient number of times to permit home range calculations. Fifty were trapped from 3 to 51 times, with an average of 16 captures/vole (Table 6). The ranges are expressed as "minimum areas" formed by a line connecting the outermost points of capture. A "minimum area" is so named because it produces an home range calculation that is 50% or less than ones calculated by other commonly employed techniques such as the "inclusive boundary strip", "exclusive boundary strip" or "Manville's method" (Crawley, 1969).

It is important to note that all methods which are used to calculate small mammal home ranges may yield unrealistic measures of the area actually utilized by a small mammal since there may be extensive areas which are never visited by the small mammal in the calculated home range (for discussions of this and other problems, see Brown, 1966; Crawley, 1969; Hayne, 1949; Kikkawa, 1964; Mohr, 1947; Riewe, 1971; Stickel, 1954). Figs. 25 and 26 depict the two largest "minimum area" home ranges found on the Aubry Lake plot and illustrate this problem. The ranges include relatively large areas where the voles were never captured and, hence, probably never utilized.

I have utilized the "minimum area" method because it has had extensive use by other investigators (such as Beer, 1961; Douglass, 1974; Hayne, 1950; Sheppe, 1966 among others) and, therefore, is useful for comparative purposes.

Another problem pertaining to the calculation of small mammal home ranges is related to the size of the trapping plot; if a plot is too small, the calculated home ranges will be smaller than the actual home ranges because animals caught near the edge over-emphasize the smaller values (Stickel, 1960; Tanaka, 1951; Tanaka and Teramura, 1953). Far too many small mammal studies can fall victim to this criticism; this study, unfortunately, is no exception. As mentioned earlier, my original plot of 2.85 ha proved to be too small and was enlarged as much as possible, given the number of traps at our disposal at the time, to 5.57 ha. Figs. 27 and 28 show the home ranges of adult male and adult female red-backed voles on the enlarged plot. Sixty percent of the adult female ranges touch the edge of the plot, and all 11 adult male ranges extend to the plot's boundary.[1] Of the 29 juvenile home ranges (not shown on the figures), 25 border on the edge of the plot. Therefore, it must be

---

[1] There is one male range of 1.90 ha shown in the centre of Fig. 27; this vole was captured 19 times between 16 and 25 July including four captures at the edge of the 2.85-ha plot. The animal died before the plot was extended, and it is not known if his actual home range lay within or surpassed the extended plot.

TABLE 6

Minimum area home ranges of red-backed voles on the Aubry Lake plot, 15 July to 5 August 1976

|  | Number of captures | Home range ($m^2$) | Number of captures | Home range ($m^2$) | Number of captures | Home range ($m^2$) | Number of captures | Home range ($m^2$) |
|---|---|---|---|---|---|---|---|---|
|  | Adult ♂ |  | Adult ♀ |  | Juvenile (♂ and ♀) |  |  |  |
|  | 5 | 300 | 25 | 3,100 | 6 | 16,600 | 24 | 1,800 |
|  | 11 | 16,000 | 5 | 300 | 19 | 2,800 | 23 | 6,000 |
|  | 6 | 500 | 18 | 1,200 | 8 | 300 | 26 | 7,800 |
|  | 3 | 300 | 5 | 1,500 | 23 | 1,200 | 8 | 6,100 |
|  | 4 | 400 | 16 | 2,600 | 4 | 600 | 21 | 4,400 |
|  | 31 | 16,500 | 7 | 400 | 14 | 1,600 | 23 | 2,200 |
|  | 19 | 19,000 | 29 | 7,200 | 6 | 100 | 35 | 10,000 |
|  | 20 | 2,800 | 18 | 2,700 | 8 | 200 | 22 | 3,800 |
|  | 51 | 39,700 | 22 | 2,300 | 9 | 2,100 | 23 | 2,900 |
|  | 4 | 1,400 | 26 | 8,000 | 8 | 2,500 | 20 | 2,600 |
|  | 35 | 4,400 |  |  | 3 | 300 | 20 | 1,800 |
|  |  |  |  |  | 7 | 1,500 | 31 | 20,800 |
|  |  |  |  |  | 3 | 700 | 15 | 4,300 |
|  |  |  |  |  | 15 | 1,200 | 9 | 5,500 |
|  |  |  |  |  |  |  | 24 | 7,400 |
| Average: | 17.2 | 9,209 | 17.1 | 2,930 |  |  | 15.8 | 4,107 |

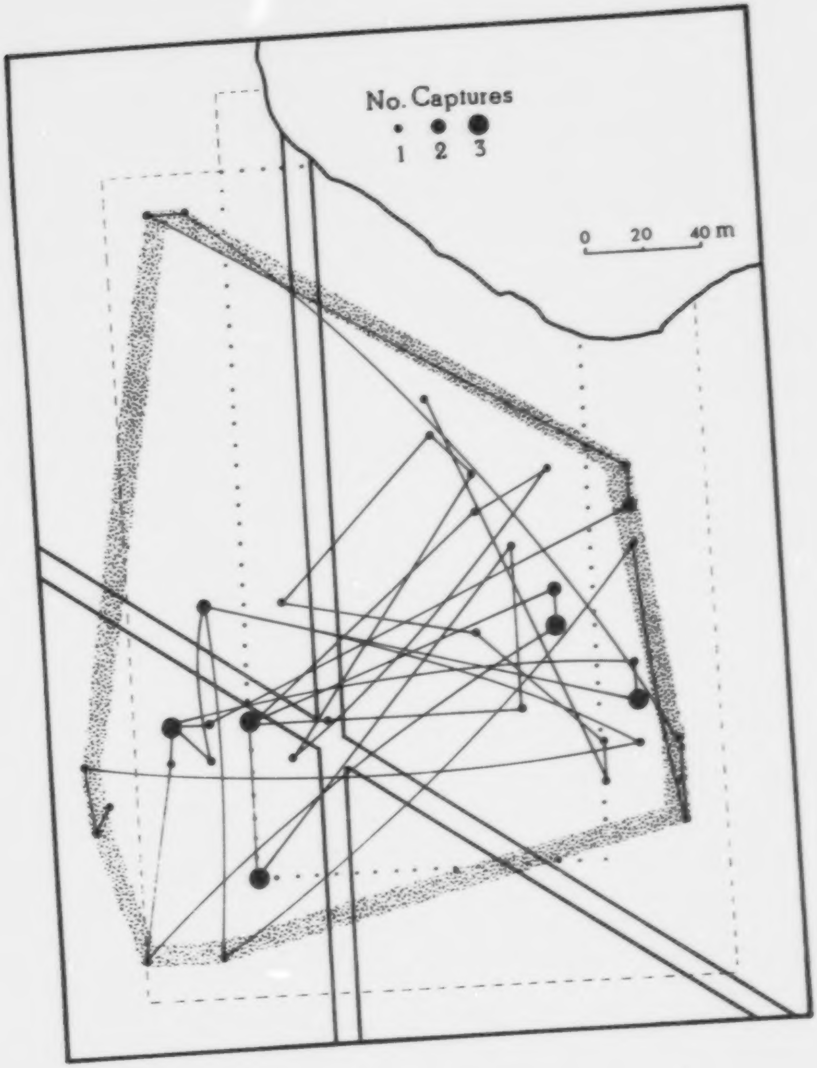

Fig. 25. The largest home range of an adult male red-backed vole on the Aubry Lake plot between 15 July and 5 August 1976. Each dot indicates a capture site; the larger the dot, the greater the number of captures. Dotted lines represent the edge of the initial 2.85-ha plot, while dashed lines indicate the final boundary of the 5.57-ha plot. Thin lines join successive capture sites. The heavy shaded line encompasses the minimum area home range of 39,700 m$^2$.

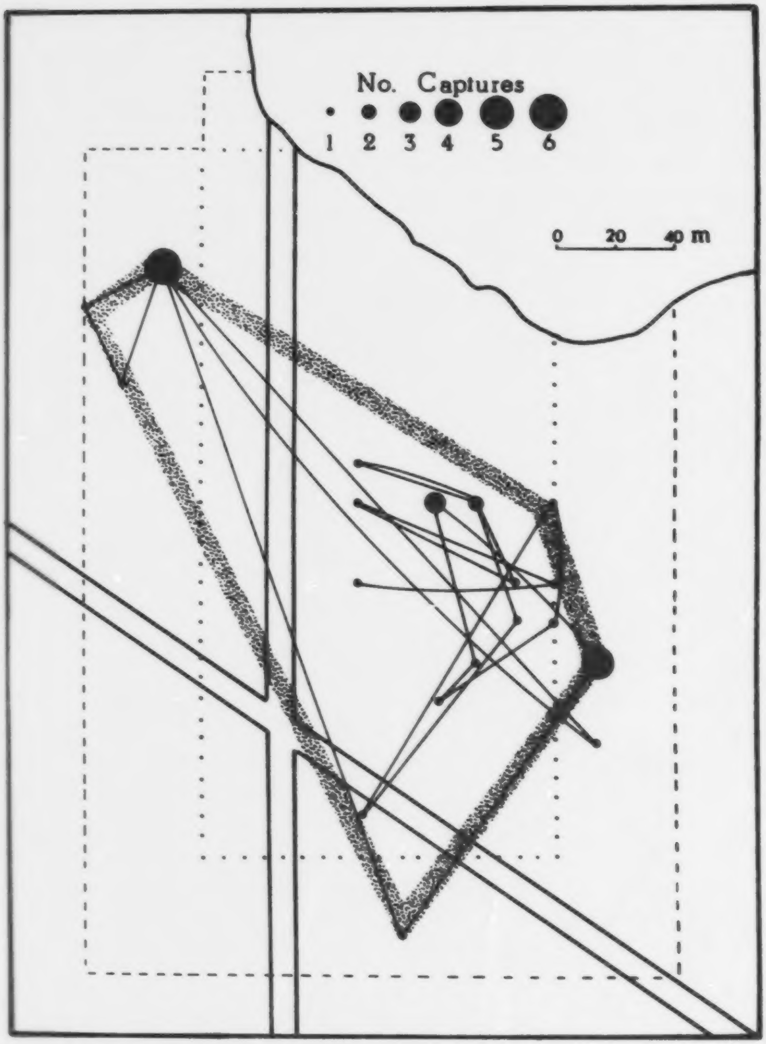
No. Captures
1
2
3
4
5
6
0
20
40 m

Fig. 26. The largest home range of a juvenile red-backed vole on the Aubry Lake plot between 15 July and 5 August 1976. Symbols as in Fig. 25. The minimum area home range is 20,800 $m^2$.

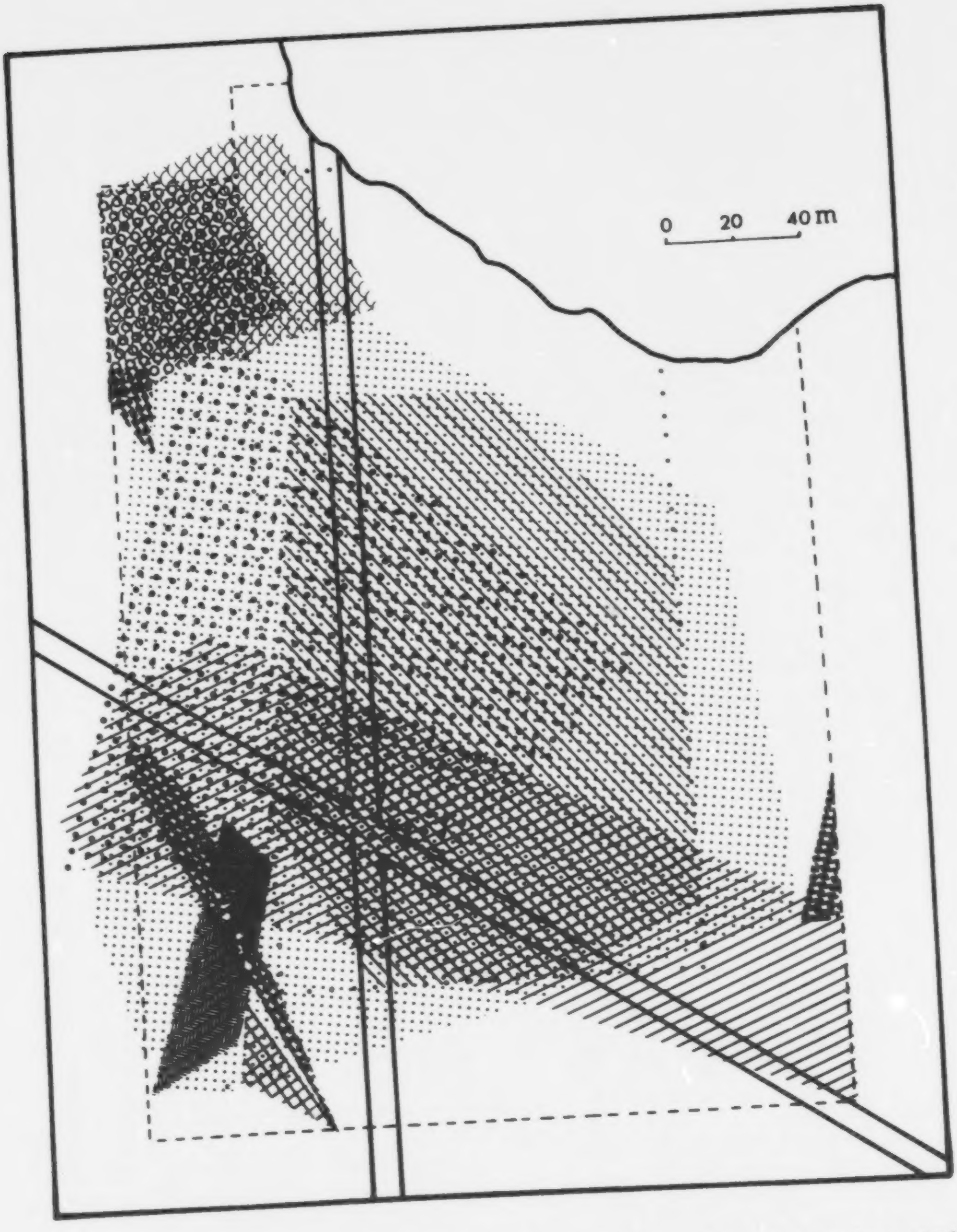

Fig. 27. Home ranges of the 11 adult male red-backed voles captured at three or more trap stations between 15 July and 5 August 1976 on the Aubry Lake plot. Dotted lines represent the edge of the initial 2.85-ha plot, while dashed lines indicate the outer boundary of the final 5.57-ha plot. The average adult male home range is 9,209 $m^2$.

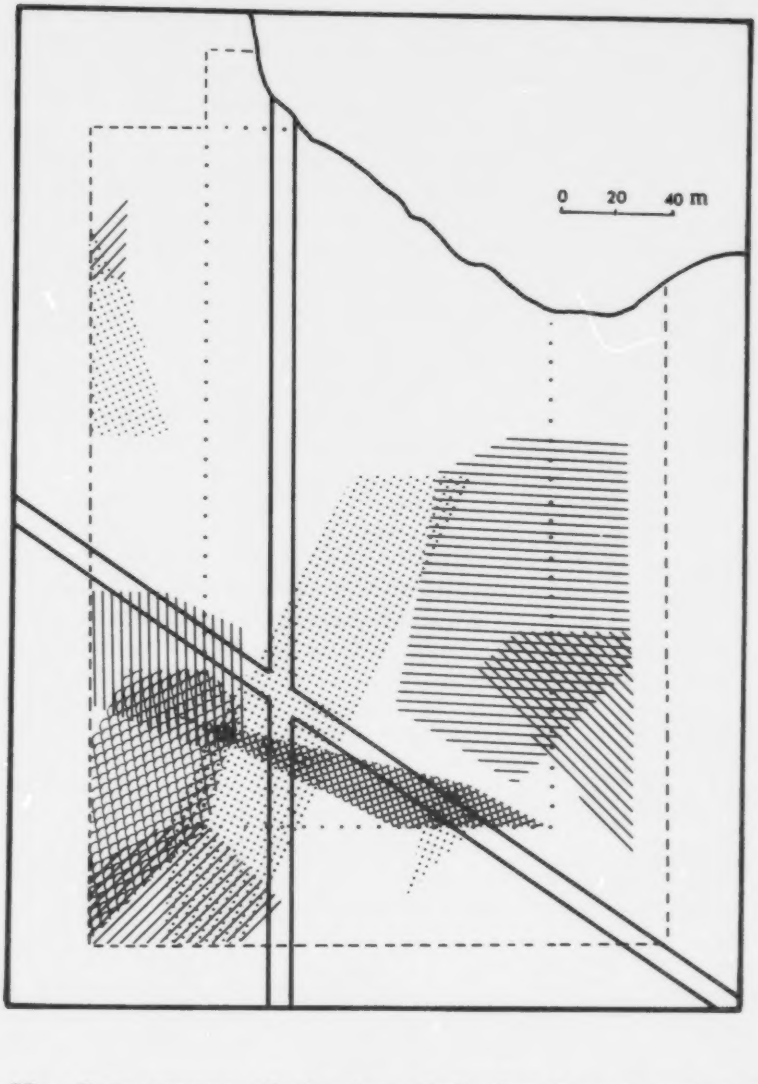

Fig. 28. Home ranges of the ten adult female red-backed voles captured at three or more trap stations between 15 July and 5 August 1976 on the Aubry Lake plot. Symbols as in Fig. 27. The average adult female home range is 2,930 $m^2$.

considered that the voles, particularly the adult males, possess larger ranges than those revealed by my trapping techniques.

Table 6 lists red-backed vole home ranges over the Aubry Lake plot from mid-July to early-August 1976. The average adult male home range of 9,209 m$^2$ (range 300 to 39,700 m$^2$) is more than three times the size of the average adult female range of 2,930 m$^2$ (range 400 to 8,000 m$^2$). This might be expected because of the females' maternal activities which keep them more closely tied to a nest site. The juvenile male and female ranges have been lumped together because of the difficulty of correctly sexing live juvenile voles. The average juvenile home range of 4,107 m$^2$ is intermediate in size between those of the adult males and adult females. The average home range for males and females, adults and juveniles combined, is 4,994 m$^2$. These relatively large home ranges are not due to the shifting of home ranges from one part of the plot to another; they are simply the result of long, rapid and frequent movements. Figs. 25 and 26 substantiate this point.

Most other studies conducted elsewhere on red-backed voles have found that this vole possesses smaller home ranges than I discovered at Aubry Lake. Douglass (1974) at Chick Lake, N.W.T. (210 km south-southwest of my study plot) employed comparable trapping methods (5-ha plots, 15.25 m x 15.25 m grid spacing, Sherman live traps set for 10 days each month from July to October and checked twice daily) and found that the average minimum area home range of *Clethrionomys rutilus* varies considerably from 233 m$^2$ for juvenile males to the largest of 3,074 m$^2$ for subadult females. He did not find any significant difference between overall male and female home ranges.

Investigations of *Clethrionomys gapperi* elsewhere in North America, often using different techniques, have discovered that this closely related species also has a variable home range size. Blair (1940a) reported the largest range of 5,018 m$^2$. Other authors reported considerably smaller ranges; for example, Marshall (cited in Gunderson, 1950) noted an average range of 2,833 m$^2$, while Gunderson (1950) and Beer (1961) discovered even smaller ranges of 931 m$^2$ and 971 m$^2$, respectively.

The home range of the bank vole, *Clethrionomys glareolus*, the European counterpart of the red-backed vole, has also been examined by several authors. Crawley (1969) noted that the bank vole possesses an average range of 753 m$^2$. Bergstedt (1966) mentioned that there was a difference between average male (2,000 m$^2$) and female (600 m$^2$) ranges; similarly, Kikkawa (1964) found an average male range of 2,208 m$^2$ and female range of 1,124 m$^2$. Brown (1954), on the other hand, found less difference in the size of the ranges of males (1,800 m$^2$) and females (1,400 m$^2$).

Obviously, the home range of a species may vary considerably in size within limits. It is generally believed that home range size is related to the size and food habits of an animal (McNab, 1963), and several studies on small rodents have shown that home range size is inversely affected by habitat quality (Beer, 1961; Layne, 1954; Riewe, 1971; Sheppe, 1966; Stickel, 1960). It has also been mentioned that age affects home range size (Burt, 1943) and that male rodents often possess larger home ranges than females, particularly during the breeding season (Bergstedt, 1966; Blair, 1940b; Getz, 1961; Howell, 1954; Van Vleck, 1969).

The larger home ranges for red-backed voles at Aubry Lake are probably related to the low biological diversity in the study area relative to other areas studied; the relatively lower biological diversity (and perhaps productivity) would force the voles to utilize larger areas in order to procure their food requirements. Even the nearby Chick Lake site has far greater diversity in terms of vegetation and physiography (Gubbe and Janz, 1974; Gubbe, 1974) which probably accounts for the smaller red-backed vole home ranges reported by Douglass (1974).

### 4.4.4 Effects of Cut Lines on Small Mammals

All small mammal captures on the Aubry Lake plot are recorded in Fig. 29. On the seismic lines crossing the plot, there were only 29 captures in 605 TN or 4.8 captures/100 TN, while off the lines in the spruce-lichen forest there were 904 captures in 2,923 TN or 30.9 captures/100 TN. Each trap off the seismic lines was visited by the small mammals 6.4 times as frequently as each trap on the lines, thus indicating a marked avoidance of the seismic lines. Even though the voles did not regularly utilize the seismic lines on the plot, the data suggest that they readily crossed the lines. At least one of the seismic lines on the plot was crossed by 23 or 46% of the red-backed vole home ranges.

The trapping data from the standard traplines used in 1976 and 1977 further substantiate the findings from the mark-recapture plot. In 19,320 TN, a total of 178 mammals or 1.84/100 TN was captured on the seismic lines, while 613 small mammals or 6.35/100 TN were captured on the undisturbed control lines.

Meadow voles were more abundant on the older seismic lines at the south end of Aubry Lake in the moist thermokarst areas than on the adjacent control lines in the spruce-lichen forest. Twenty-six meadow voles were caught in moist sites on the seismic lines, but only a single individual was taken from an undisturbed site. Twenty-eight red-backed voles were also caught in moist sites on the seismic lines, while four others were taken from drier portions of the lines. Even though the thermokarst slumps on the seismic lines provide habitat for the meadow voles, the number of *Microtus* do not compensate for the apparent decline in *Clethrionomys*; 176 red-backed voles were taken on the control lines versus 32 meadow voles on the seismic lines.

The data also indicate that the bulldozer trails which crisscross traplines 12B and 13B were even less productive in terms of small mammals

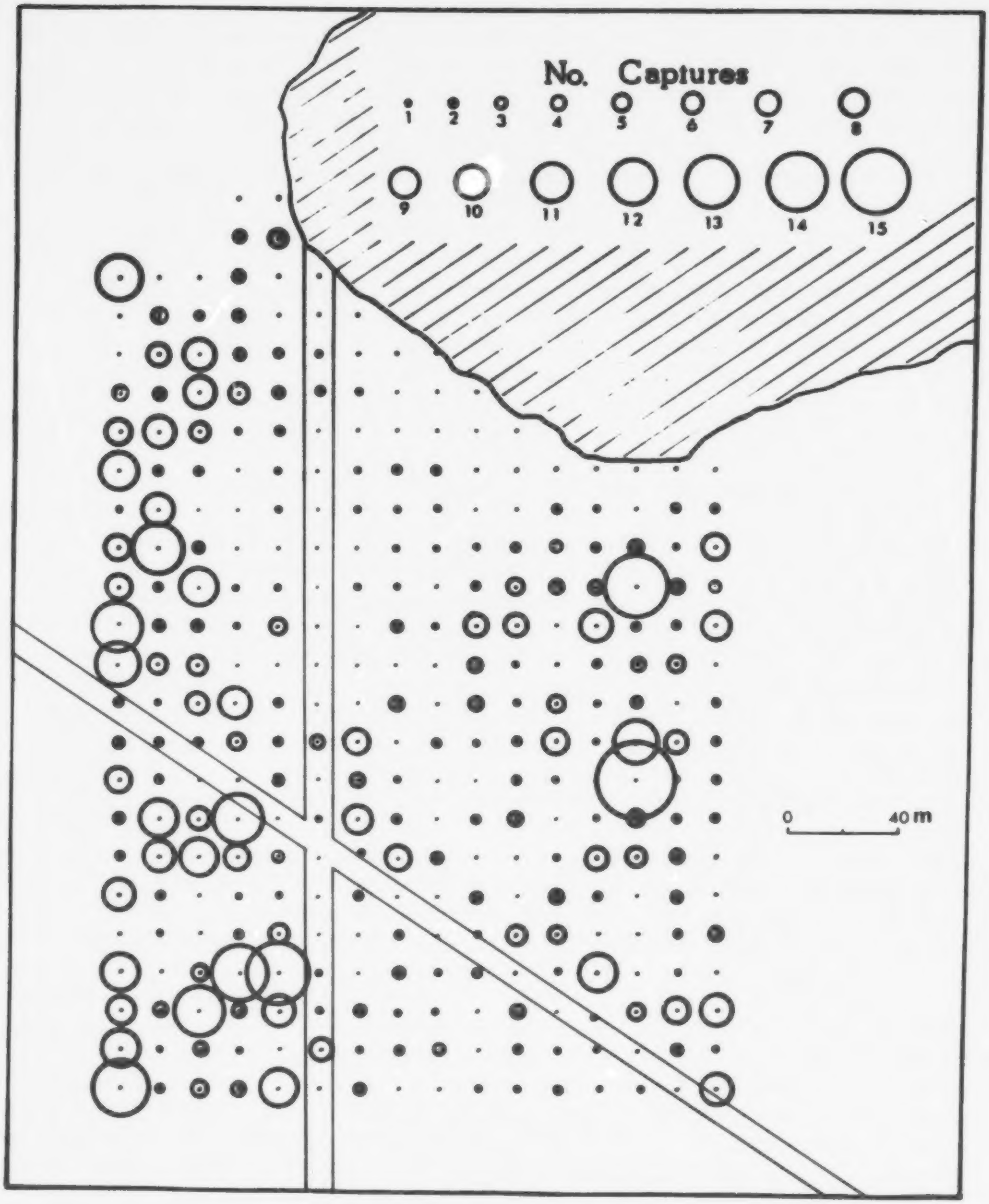
No. Captures
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
40 m

Fig. 29. Aubry Lake mark-recapture plot showing the total number of small mammal captures at each trap station. Each dot indicates a trap station; the larger the circle surrounding the station, the greater the number of captures. Each trap off the seismic lines was visited by the small mammals 6.4 times as frequently as each trap on the seismic lines.

than were the neighbouring seismic lines. On lines 12B and 13B, 29 (20.7%) of the 140 traps were set on the meandering bulldozer trails. Only 3 (8.1%) of the 37 voles were captured on these Cat trails; all the rest were caught in the undisturbed forest.

Martell (1972), working on the tundra uplands east of the Mackenzie Delta, noted that seismic lines cut or used in the summer display a change in plant communities which appears to exclude red-backed voles and collared lemmings (*Dicrostonyx torquatus*) and attract meadow voles. Seismic lines cut or used in winter, however, tend to retain the same plant associations but possess a reduced plant cover. The decrease in plant cover apparently prevents red-backed voles from spending much time on the lines, but it does not prevent them from crossing the lines.

Boles (1975) who studied several sites along the Mackenzie valley between Fort Good Hope and the Delta found the red-backed vole to be the most common mammal in the region. However, in old seismic lines with grassy vegetation, meadow voles are frequently present.

While Douglass (1974) conducted his study at Chick Lake, he had the opportunity to assess the effects of a new cut line (4 to 5 m in width) upon the small mammals. His data indicate that a narrow cut line has no immediate effect on the movements of small mammals. He mentioned, however, that a wider cut line, coupled with disturbance of ground cover, would be more likely to disrupt the movements of small mammals.

### 4.4.5 Habitat Utilization by Red-Backed Voles on the Mark-Recapture Plot

A comparison of Fig. 7 and Fig. 29 reveals that red-backed voles were not captured along the pond margin (area I). Prior to the establishment of the mark-recapture plot, an exploratory trapline (Table 2, line 7) was set along the shore of the pond, and 13 chestnut-cheeked voles and 3 red-backed voles were kill-trapped. Only one red-backed vole was captured along the portion of the pond margin included in the boundary of the plot.

Except for the lack of activity along the pond margin and a scarcity of activity on the seismic lines, red-backed voles utilized all other habitats on the plot. Two areas, the central portion of area IV and the southern portion of area VI, displayed minimal activity. No reason can be found to explain why these areas were avoided by the voles.

## 4.5 Snow Conditions during April and May 1977

Local residents said that they had experienced above average snowfall during the 1976-77 winter season. Table 7 gives a schedule of snow data collected during the spring field season (10 April to 1 May)

# TABLE 7

## Snow station data collected in the Aubry-Colville Lakes area, 10 April to 1 May 1977

| Terrain | Date | Pukak temperature (°C) | Layer 1 | | | | | Layer 2 | | | | | Layer 3 | | | | | Layer 4 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Depth (cm) | Hardness (g/cm²) | Density (g/cc) | Crystal type† | Maximum crystal size (cm) | Depth (cm) | Hardness (g/cm²) | Density (g/cc) | Crystal type† | Maximum crystal size (cm) | Depth (cm) | Hardness (g/cm²) | Density (g/cc) | Crystal type† | Maximum crystal size (cm) | Depth (cm) | Hardness (g/cm²) | Density (g/cc) | Crystal type† | Maximum crystal size (cm) |
| Seismic lines | | | | | | | | | | | | | | | | | | | | | | |
| On hill | 10 April | -3.0 | 38 | 36.6 | 0.290 | P | 8 | 39 | 725.0* | | I | | 69 | 28.1 | 0.203 | OS | 2.5 | 84 | 8.0 | 0.130 | SS | 1 |
| On hill | 14 April | -4.0 | 51 | 439.5 | 0.335 | P | 8 | 52 | 2,666.7* | | I | | 73 | 85.0 | 0.280 | OS | 3.0 | 96 | 80.0 | 0.140 | OS | 1 |
| On hill | 15 April | -2.0 | 42 | 392.5 | 0.280 | P | 10 | 43 | 1,666.7* | | I | | 76 | 56.3 | 0.260 | OS | 3.0 | 91 | 21.7 | 0.150 | OS | 2 |
| On slope | 10 April | -4.0 | 39 | 172.9 | 0.240 | P | 7 | 40 | 70.0* | | I | | 65 | 71.0 | 0.215 | OS | 3.0 | 90 | 20.0 | 0.130 | SS | 2 |
| On slope | 14 April | -2.0 | 44 | 225.7 | 0.295 | P | 8 | 45 | 3,750.0* | | I | | 79 | 48.6 | 0.255 | OS | 3.0 | 91 | 21.7 | 0.180 | SS | 2 |
| On slope | 15 April | -1.5 | 45 | 414.3 | 0.295 | P | 12 | 46 | 1,750.0* | | I | | 80 | 65.0 | 0.280 | OS | 3.0 | 93 | 26.3 | 0.150 | OS | 1 |
| In valley | 10 April | -6.0 | 45 | 298.3 | 0.230 | P | 8 | 46 | 775.0* | | I | | 93 | 45.7 | 0.130 | OS | 1.5+ | | | | | |
| In valley | 14 April | -4.0 | 39 | 204.3 | 0.280 | P | 6 | 40 | 2,125.0* | | I | | 72 | 42.5 | 0.260 | OS | 3.0 | 83 | 15.0 | 0.140 | SS | 2 |
| In valley | 15 April | -3.5 | 43 | 333.1 | 0.240 | P | 10 | 44 | 1,333.3* | | I | | 75 | 151.9 | 0.290 | OS | 2.0 | 86 | 20.0 | 0.125 | OS | 1 |
| Control (bush) lines | | | | | | | | | | | | | | | | | | | | | | |
| On hill | 14 April | -5.5 | 34 | 145.0 | 0.270 | P | 4 | 35 | 1,166.7* | | I | | 71 | 40.7 | 0.255 | OS | 2.0 | 86 | 21.7 | 0.140 | OS | 1 |
| On hill | 15 April | -2.5 | 37 | 338.1 | 0.315 | P | 6 | 38 | 1,833.3* | | I | | 75 | 64.4 | 0.280 | OS | 2.0 | 92 | 28.8 | 0.155 | OS | 1 |
| On slope | 10 April | -6.0 | 33 | 28.3 | 0.210 | P | 5 | 34 | 480.0* | | I | | 63 | 53.3 | 0.230 | OS | 2.0 | 77 | 7.3 | 0.150 | OS | 1 |
| On slope | 14 April | -6.0 | 43 | 257.5 | 0.350 | P | 5 | 44 | 1,500.0* | | I | | 78 | 60.0 | 0.275 | OS | 1.0 | 92 | 17.5 | 0.130 | SS | 1 |
| On slope | 15 April | -4.0 | 44 | 359.4 | 0.330 | P | 6 | 45 | 2,625.0* | | I | | 82 | 60.7 | 0.285 | OS | 4.0 | 93 | 21.3 | 0.140 | OS | 2 |
| In valley | 14 April | -6.0 | 38 | 155.0 | 0.270 | P | 6 | 39 | 2,166.0* | | I | | 82 | 60.6 | 0.195 | OS | 2.0+ | | | | | |
| In valley | 14 April | -6.0 | 36 | 158.9 | 0.280 | P | 7 | 37 | 1,875.0* | | I | | 68 | 146.7 | 0.275 | OS | 2.0 | 78 | 80.0 | 0.140 | OS | 1 |
| Others | | | | | | | | | | | | | | | | | | | | | | |
| Along shoreline | 10 April | -2.0 | 41 | 244.6 | 0.245 | P | 10 | 42 | 600.0* | | I | | 78 | 20.0 | 0.215 | OS | 1.0 | 90 | | 0.115 | SS | 1 |
| On open lake | 14 April | -0.5 | 10 | 1,190.0 | 0.260 | P | 8 | 11 | 237.5* | | I | | 43 | 85.0 | 0.220 | OS | 4.0 | 54 | 16.0 | 0.160 | OS | 1 |
| Caribou cratering area | 19 April | -7.0 | 30 | 154.0 | 0.265 | P | 5 | 31 | 1,500.0* | | I | | 48 | 300.0 | 0.270 | OS | 2.0 | 68 | 42.5 | 0.160 | OS | 2 |
| Caribou cratering area | 1 May | -8.0 | 10 | 2,750.0 | 0.370 | P | 10 | 33 | 10,333.3 | 0.420 | OS | 2 | 55 | 125.0 | 0.325 | OS | 3.0 | 59 | 1,300.0 | 0.290 | OS | 1 |

†Crystal type: P = pukak, I = ice, OS = old snow, SS = settling snow

*Vertical hardness

+Layer 3 data of this station not included in mean values calculated in text in the area of Aubry and Colville Lakes. Bush stations were generally located at right angles and 150 m from corresponding snow stations taken on seismic lines (Fig. 30). Temperatures during the sampling period averaged a daily high of -3°C and a daily low of -20°C. Thawing conditions did not seriously deteriorate the snowcover until 22 April. Prior to this, snowcover in the predominant spruce-lichen forest had a mean depth of 85.7 cm (Fig. 31). Snow station profiles typically consisted of four layers (Table 8):

(1) The bottom pukak (hoar frost crystals formed at the base of the snowcover) layer averaged a depth of 37.9 cm, hardness 206 g/cm$^2$ and density 0.289 g/cc

(2) An old melt crust averaging 1 cm thick with a vertical hardness of 1,663.8 g/cm$^2$

(3) A layer of old snow crystals 33.9 cm average thickness with a mean hardness and density of 71 g/cm$^2$ and 0.267 g/cc, respectively

(4) A top layer of settling snow or old snow averaging 12.9 cm thick with a mean hardness of 29.4 g/cm$^2$ and density of 0.143 g/cc

Qali [snow which collects in the trees (Fig. 32) and later falls onto the snow covering the ground] blobs of varying hardness and size were occasionally encountered in exposed profiles but did not figure greatly in average snow conditions due to the low density of trees.

Two representative snow stations were taken to sample a shoreline and lake ice for comparative purposes (Table 7). Shorelines were generally characterized by fairly deep snow due to drift build-up, whereas the total depth of 54 cm shown for the snow station on lake ice (Table 7) was representative of large open lake areas.

Comparisons between average snow characteristics of profiles exposed on seismic lines and in the bush cannot provide reliable conclusions due to the small sample sizes. However, comparisons between mean conditions for these profiles suggest significant differences in total depth, depth of pukak, temperature of pukak and pukak crystal size. Average total snow depth on the seismic lines for the period 10 to 15 April 1977 was 89.7 cm (n = 9) as compared to 85.7 cm (n = 7) in the bush. This difference is significant only at a 90% confidence level (student's "t" test, $p<0.1$). Significant differences appear to exist with the depth of pukak (seismic lines significantly greater, student's "t" test, $p<0.05$), temperature of pukak (seismic lines significantly greater, student's "t" test, $p<0.01$) and pukak crystal size (seismic lines significantly greater, student's "t" test, $p<0.01$). These relationships point out the possibility that differences in snowcover characteristics on and off seismic lines may have a differential effect upon the movement behaviour of some animals,

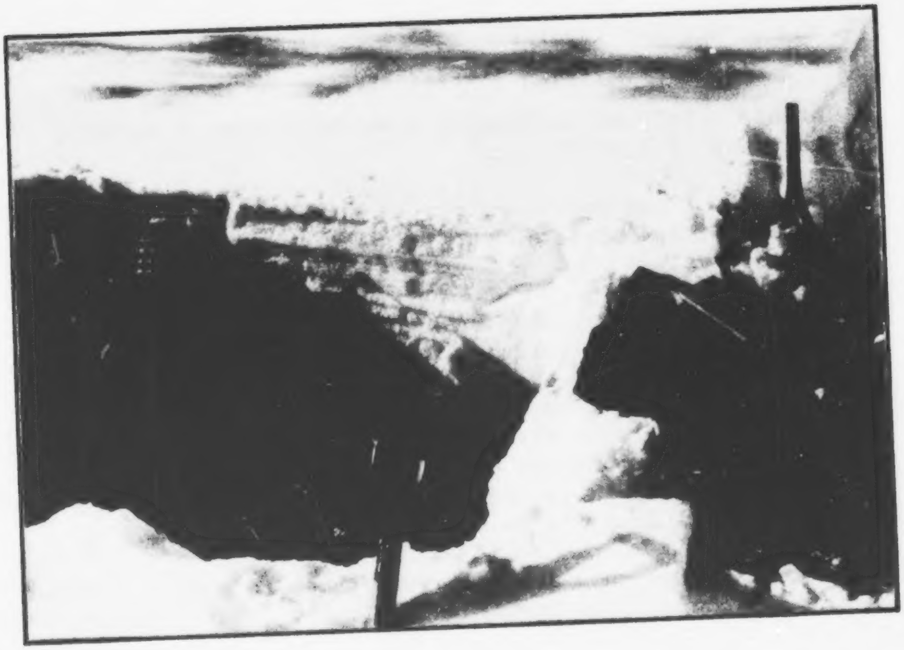

Fig. 30. Hardness measurements being taken at a snow station along a seismic line.

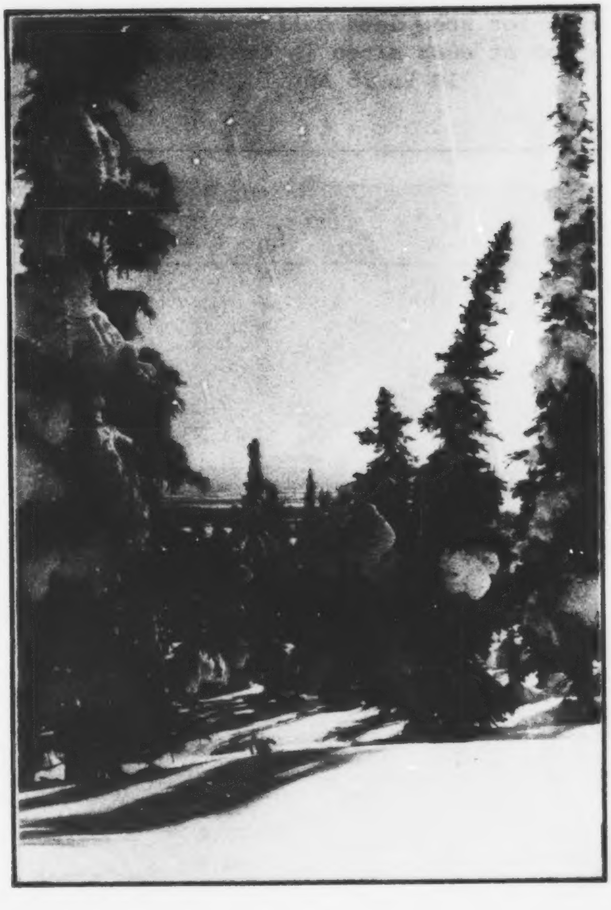

Fig. 31. Snow accumulation in the spruce-lichen forest in the Aubry-Colville area varied from 60 to 120 cm in April 1977.

## TABLE 8

Mean values for snow data collected at snow stations on seismic lines and at bush sites in the Aubry-Colville Lakes area, 10 to 15 April 1977

| | Seismic line stations (n = 9) | Control (bush) stations (n = 7) |
|---|---|---|
| $\bar{x}$ pukak temperature (°C) | -3.33 | -5.14 |
| Layer 1 | | |
| $\bar{x}$ depth (cm) | 42.9 | 37.9 |
| $\bar{x}$ hardness (g/cm$^2$) | 279.7 | 206.0 |
| $\bar{x}$ density (g/cc) | 0.276 | 0.289 |
| $\bar{x}$ crystal type† | P | P |
| $\bar{x}$ maximum crystal size (cm) | 8.6 | 5.6 |
| Layer 2 | | |
| $\bar{x}$ depth (cm) | 43.9 | 38.9 |
| $\bar{x}$ hardness (g/cm$^2$) | 1,651.3* | 1,663.8* |
| $\bar{x}$ density (g/cc) | | |
| $\bar{x}$ crystal type† | I | I |
| $\bar{x}$ maximum crystal size (cm) | | |
| Layer 3 | | |
| $\bar{x}$ depth (cm) | 73.6 | 72.8 |
| $\bar{x}$ hardness (g/cm$^2$) | 68.6 | 71.0 |
| $\bar{x}$ density (g/cc) | 0.255 | 0.267 |
| $\bar{x}$ crystal type† | OS | OS |
| $\bar{x}$ maximum crystal size (cm) | 2.8 | 2.2 |
| Layer 4 | | |
| $\bar{x}$ depth (cm) | 89.7 | 85.7 |
| $\bar{x}$ hardness (g/cm$^2$) | 26.6 | 29.4 |
| $\bar{x}$ density (g/cc) | 0.143 | 0.143 |
| $\bar{x}$ crystal type† | SS | SS |
| $\bar{x}$ maximum crystal size (cm) | 2.0 | 1.8 |

†Crystal type: P = pukak, I = ice, OS = old snow, SS = settling snow

*Vertical hardness

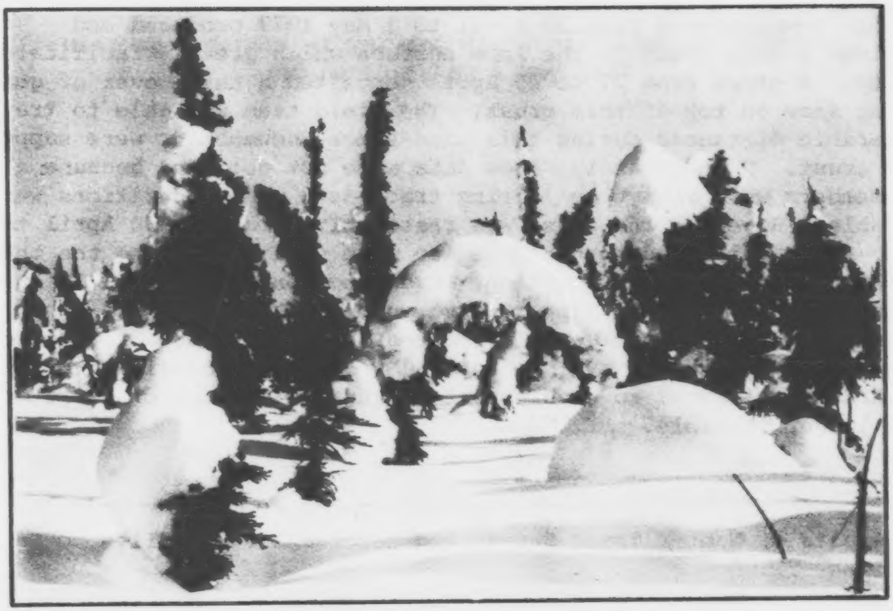

Fig. 32. Heavy qali (snow which accumulates in trees) loads on white spruce.

especially those exhibiting subnivean (below the snowcover) movement. Further investigation may be warranted here.

Subsequent to 22 April 1977, snowcover in the Aubry-Colville area deteriorated severely due to two successive thaws during which temperatures climbed as high as 19°C. A series of snow depth readings at various distances from a shoreline were taken on 1 May to show the decrease in total snow depth to that date (Table 9). Average snow depth in the bush had decreased to 69.6 cm ($n = 7$, 300 m from a shoreline) from the previous mean of 85.7 cm ($n = 7$).

Cold temperatures from 28 April to 1 May 1977 produced and maintained a melt crust on the snow surface which greatly facilitated mobility. A storm from 27 to 29 April deposited a thin cover of good tracking snow on top of this crust. The field team was able to travel considerable distances during this time since snowmobiles were supported by the crust. Unfortunately, snow data were not obtained because all field members were active collecting track data while conditions were favourable. However, the crust was reasonably hard from 30 April to 2 May. Areas which had been exposed to more sunlight during the thaw experienced harder crust formation. Crusting conditions from 30 April to 2 May were observed to support caribou but not moose. All other animals exhibiting supranivean (above the snowcover) locomotion were observed to be supported by the crust. By 3 May the condition of this crust had deteriorated to such an extent that collection of field data was no longer feasible.

## 4.6 Results of Winter Track Survey and Reactions of Wildlife to Seismic Lines

### 4.6.1 Willow Ptarmigan

Willow ptarmigan are the most noticeable and most abundant of the terrestrial wildlife in the study area. They were found wherever there were willows. Along the 20.2 km of surveyed rivers and creeks (Fig. 33) there was an average of 81.44 ptarmigan tracks/km. On lakes, which were surveyed 25 m or more from shore, ptarmigan sign was scarce, but the entire shorelines were laced with innumerable tracks among the willows.

There was far more ptarmigan sign on the control bush lines than on either the 1973-75 or 1969 seismic lines. Of the 2,606 tracks recorded along the seismic lines, all but 62 (2.4%) crossed the seismic lines at right angles, indicating very little use of the seismic lines. There were, however, numerous tracks of ptarmigan feeding in willows along the edge of the seismic lines, but these tracks were not recorded if they did not enter the open portion of the seismic line. In a few areas where willows stood above the snowcover, ptarmigan freely fed upon the willow

TABLE 9

Mean snow depths at varying distances from the shoreline of Aubry Lake, 1 May 1977

| Distance from shoreline | No. of readings | $\bar{x}$ depth (cm) | Range (cm) |
|---|---|---|---|
| At shoreline | 7 | 65.6 | 49-75 |
| 50 to 100 m in midst of caribou craters | 13 | 65.9 | 49-75 |
| 100 m | 6 | 69.3 | 56-80 |
| 200 m | 7 | 67.4 | 59-76 |
| 300 m | 7 | 69.6 | 65-75 |

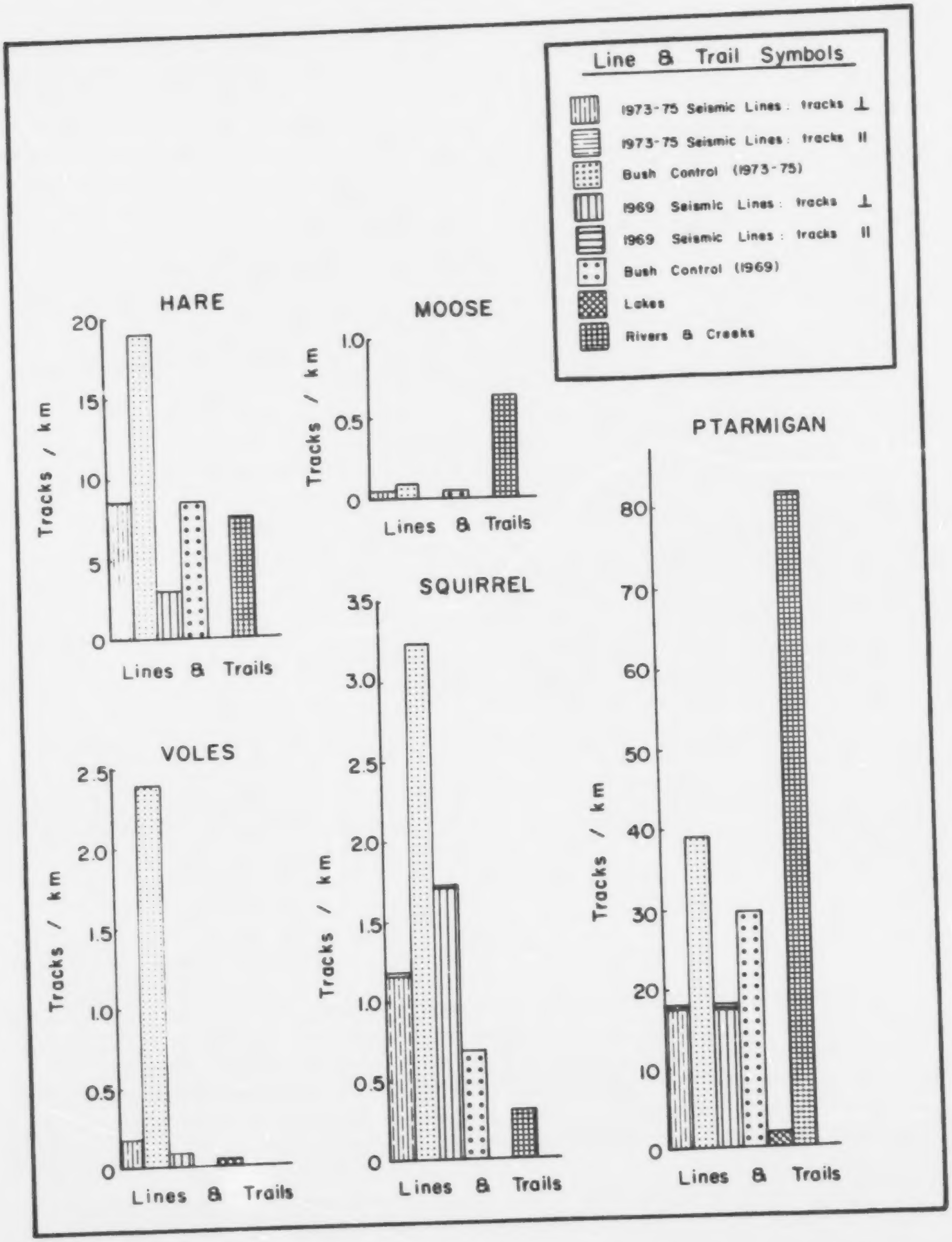

Fig. 33. Reactions of wildlife to seismic lines in the Aubry-Colville Lakes region during April and May 1977. Histograms indicate the relative activity of wildlife along seismic lines as compared to control areas in the bush or along rivers, creeks and lakes. Tracks recorded on seismic lines have been subdivided into those which followed the lines and those which merely crossed the lines at right angles.

. . . continued

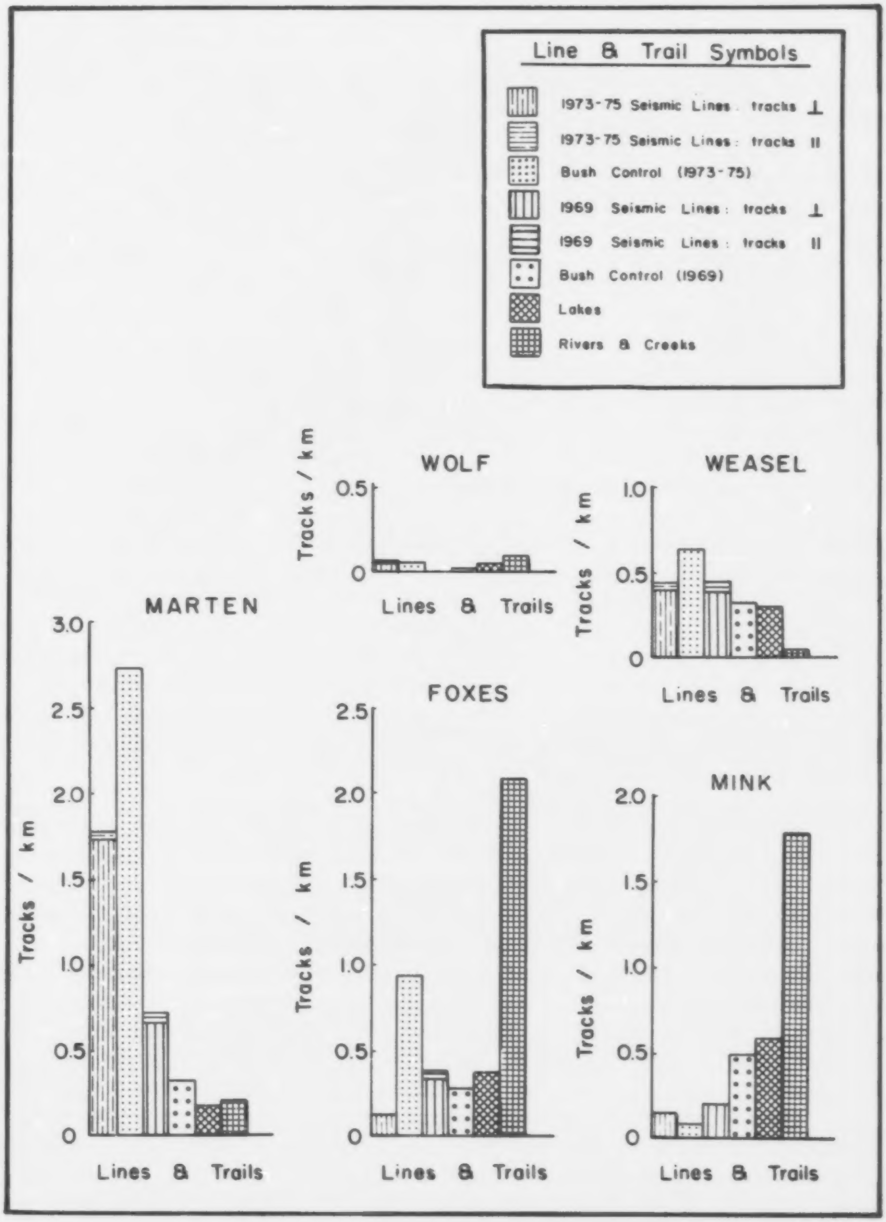

Fig. 33. Reactions of wildlife to seismic lines in the Aubry-Colville Lakes region during April and May 1977 (continued).

buds (Fig. 34). On one occasion we dug into the snow on a 1969 seismic line and uncovered willows which had previously been fed upon by ptarmigan.

Ptarmigan appear to be indifferent to seismic lines; they are neither attracted nor repelled by the lines, unless there is exposed willow and then the birds do not hesitate to feed on the line. In this regard, ptarmigan react to seismic lines as they do to exposed areas along rivers and lakes.

### 4.6.2 Voles and Lemmings

During winter voles and lemmings usually restrict their activity to the mild subnivean microenvironment; only occasionally do they make excursions into the harsh supranivean world. Therefore, only rarely are their tracks encountered on the snow surface. Under a snowcover $CO_2$ may accumulate due to bacterial decomposition. Voles rid their burrows of excessive $CO_2$ by tunnelling up to the snow surface and allowing the gas to escape into the atmosphere. Ventilation shafts appear as small burrows 2 to 3 cm in diameter on the snow surface (Fig. 35). Only rarely are there tracks on the snow leading to or from the opening of the shafts. The denser the microtine population, the greater the number of ventilation shafts. Ventilation shafts therefore can be used as a relative indicator of vole density. Unfortunately, due to their small size, ventilation shafts can easily be overlooked under poor lighting conditions. Although ventilation shafts were recorded during the spring survey, undoubtedly many were inadvertently overlooked.

Many more ventilation shafts were noted in bush at the north end of Aubry Lake than elsewhere. In this area, we encountered two small vole colonies. One colony had 19 shafts in an area 15 m in diameter. This colony was situated in a small sedge swale in the spruce forest beneath 76 cm of snow. The second colony with 70 shafts in an area 20 m in diameter was located on the shore of Aubry Lake also among sedges. These two colonies accounted for 76% of all ventilation shafts recorded. Thirteen of the 19 shafts noted on 1973 and 1969 seismic lines were lone holes; only one cluster of six shafts was found, indicating a small vole colony. This colony was located in a natural sedge swale traversing the seismic line. Therefore this colony cannot be considered to have been utilizing habitat created by thermokarst activity resultant from cutting the line. Thus only 13 ventilation shafts were noted on 145 km of seismic lines. These observations suggest that seismic lines are no more beneficial to microtines in winter than they are in summer.

### 4.6.3 Red Squirrel

Red squirrel sign was widely scattered, most commonly being noted in

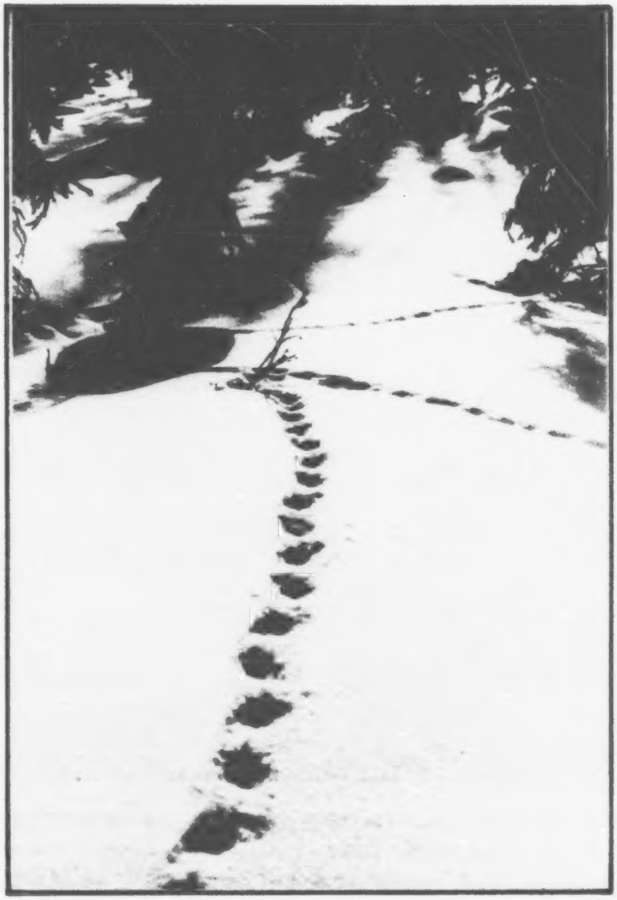

Fig. 34.  Sign of ptarmigan feeding on exposed willow buds.

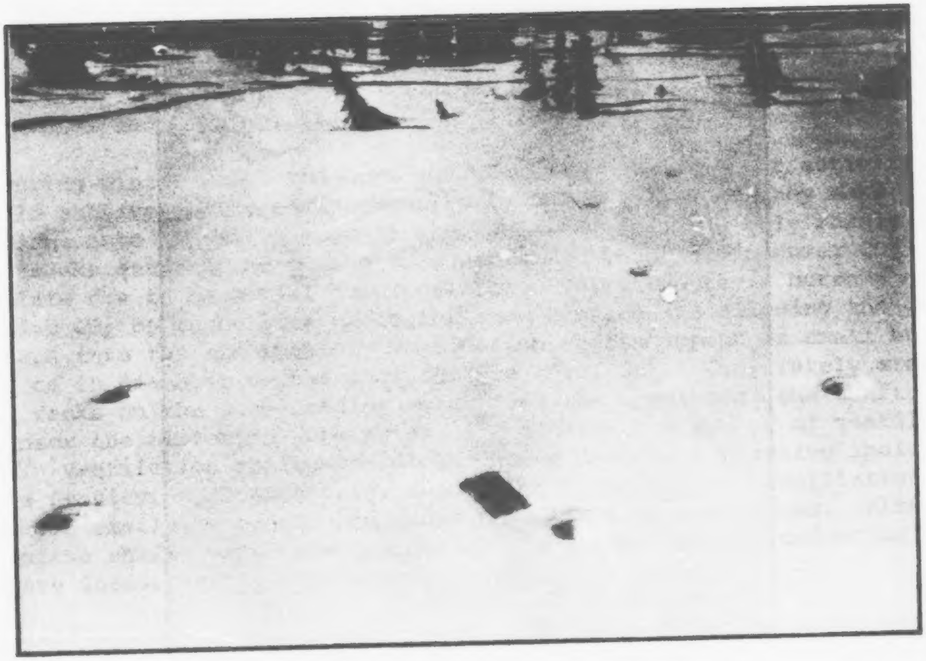

Fig. 35. Openings of ventilation shafts in a small sedge swale. These shafts identify a subnivean vole colony. Note the lack of tracks leading to or from shaft openings.

spruce forest and to a lesser extent crossing rivers and creeks. There was more than twice as much squirrel sign on the bush control trails running parallel to the 1973-75 seismic lines as on the seismic lines. On 1969 seismic lines the reverse situation was encountered: there was more than twice the sign on the lines as on the control trails. All 213 tracks recorded on the seismic lines of all ages crossed at right angles, indicating an avoidance of the open lines (Fig. 36). Two tracks entered burrows in the center of the seismic lines, which indicates possible subnivean use of the lines. Our observations suggest that squirrels do not generally utilize seismic lines.

### 4.6.4 Snowshoe Hare

Snowshoe hares were scattered in small numbers throughout the countryside but occasionally they were concentrated in small isolated pockets. It was evident that the hares were by no means at their population peak.

There were about twice as many hare tracks recorded on the bush control trails as noted on the seismic lines (Fig. 33), indicating that they tend to avoid the open lines. Of the 846 tracks recorded on the seismic lines, all but 13 crossed the lines at right angles. Of the 13 tracks which followed seismic lines, nine of them were actually following our well-packed snowmobile or snowshoe trails. Thus, snowshoe hares tend to avoid seismic lines.

### 4.6.5 Moose

Moose are uncommon in the study area, and only 23 tracks were recorded. Thirteen (56%) of these tracks were made by a single animal which was feeding and bedding along a willow-lined creek. There was no sign of moose utilizing seismic lines for either travel routes or as feeding grounds. Five moose tracks were recorded on seismic lines, but all crossed the lines at right angles (Fig. 33).

### 4.6.6 Caribou

From 19 to 30 April 1977 a total of 1,000 to 1,500 caribou were observed, usually in scattered bands of 200 to 400 along the east shore of Aubry Lake where they were making intensive use of lake ice for travelling and loafing (Fig. 37). They were not as numerous on either the southern or western portions of Aubry Lake or on the north end of Colville Lake. When we first observed them, apparent migration activity was not obvious, although caribou were constantly moving back and forth from one shoreline location to another.

Fig. 36. Red squirrel tracks crossing a seismic line at right angles. Note the spruce tree which has been snapped off by an excessive qali load.

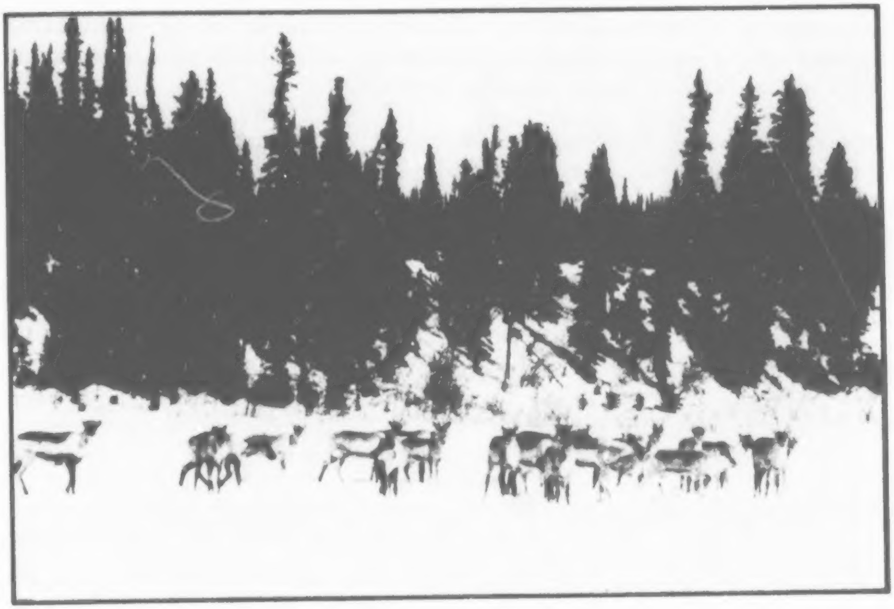

Fig. 37. Members of the Bluenose caribou herd loafing along the east shore of Aubry Lake in April 1977. The snow on the lake was relatively shallower and harder than the forest snowcover.

Caribou responded to the snow conditions during mid-April by spending most of their time on lakes and severely restricting their movement in the forest. Feeding activity was concentrated within 200 m of shorelines (Fig. 38), and caribou usually followed water routes or chains of ponds in travelling from one lake to another. It was noted on several occasions that caribou preferred to dig through previously cratered and disturbed snow rather than venture farther away from a shoreline in the deep snow of the forest. They were observed to feed mainly on ground and arboreal lichens, sedges, shrub birch and willows. Some feeding craters were occasionally observed on seismic lines, but the limited incidence of such activity is not considered to be significant. In most cases, there was a marked absence of cratering on seismic lines that traversed a feeding area near a shoreline.

There are several factors which influence an analysis of caribou activity with respect to seismic lines:

1. As mentioned, above-threshold nivean conditions tended to restrict caribou activity to areas adjacent to lakes and waterways. This factor precludes a high degree of interaction between caribou and seismic lines.

2. Field investigations were designed primarily to sample furbearer activity and were not compatible with either the observed clumped distribution of caribou activity or the gregarious behaviour of the animals.

3. The tendency of large numbers of caribou to follow line-of-file through deep snow prevented any quantitative estimates of activity since the trails would only signify the passage of two or more animals (Fig. 39). The majority of caribou activity areas observed were so intensively trampled and disturbed that quantitative descriptions could not be made.

4. Seismic lines which came out to shorelines utilized by caribou were generally oriented at approximately right angles to the shorelines. Since the majority of caribou movements were generally parallel to shorelines, the incentive to follow seismic lines was less pronounced.

Caribou activity was observed on seismic lines on only 27 occasions. Twenty of these observations occurred prior to severe deterioration of the snowcover due to spring thawing conditions (22 April). During this time, caribou trails were observed to follow seismic lines on 10 occasions for an average distance of 0.5 km. Seven of these observations took place more than 0.5 km from a shoreline, where caribou came onto a seismic line, followed it for a short distance and then left it. The remaining three observations were from seismic lines oriented at more or less right angles to a shoreline, where caribou trails followed the cleared lines down to the shore. On all occasions caribou had been

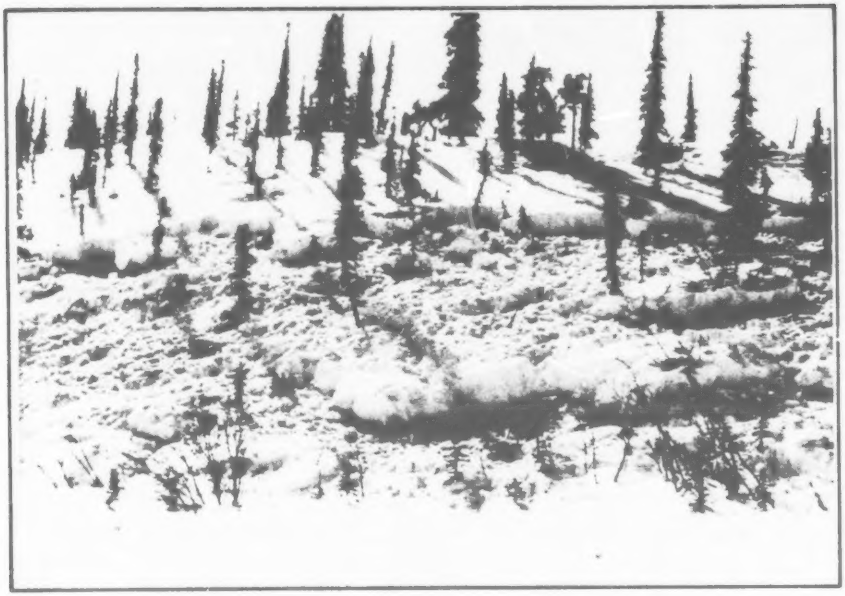

Fig. 38. Caribou feeding sign along the shoreline of Aubry Lake, April 1977. Due to the deep snowcover in the forest, the caribou usually fed within 200 m of the shoreline.

North of 60

Environmental Studies No. 9

# Interactions Between Wildlife, Trapper-Hunters and Seismic Lines in the Mackenzie Valley Region, N.W.T., Canada

## Part I

## Aubry-Colville Lakes

Environmental Studies No. 9

# Interactions Between Wildlife, Trapper-Hunters and Seismic Lines in the Mackenzie Valley Region, N.W.T., Canada.
## Part I
## Aubry-Colville Lakes

R.R. Riewe
R and R Research Limited
Winnipeg, Manitoba

© Published under authority of the
Hon. J. Hugh Faulkner, Minister
of Indian and Northern Affairs Canada,
Ottawa, 1979.
QS-8203-000-EE-AI
Catalogue No. R71-19/9-1979
ISBN 0-662-10429-3

This report was prepared under contract for the Arctic Land Use Research Program, Northern Environmental Protection and Renewable Resources Branch, Department of Indian Affairs and Northern Development.

The views, conclusions and recommendations expressed herein are those of the author and not necessarily those of the Department.

Cette publication peut aussi être obtenue en français.

TABLE OF CONTENTS

Page

1. Summary . . . . . . . . . . . . . . . . . . . . . . . . . 1

2. Introduction . . . . . . . . . . . . . . . . . . . . . . 3

  2.1 Objective . . . . . . . . . . . . . . . . . . . . . . 3
  2.2 Study Area . . . . . . . . . . . . . . . . . . . . . . 3

    2.2.1 Study Sites and Field Operations . . . . . . . . . . 3
    2.2.2 Physiography of the Study Area . . . . . . . . . . . 8
    2.2.3 Climate of the Study Area . . . . . . . . . . . . . 8
    2.2.4 Habitats in the Study Area . . . . . . . . . . . . . 8
    2.2.5 Wildlife in the Study Area . . . . . . . . . . . . . 9

3. Methods . . . . . . . . . . . . . . . . . . . . . . . . . 10

  3.1 Floral and Disturbance Studies . . . . . . . . . . . . 10

    3.1.1 Botanical Collections . . . . . . . . . . . . . . . 10
    3.1.2 Vegetative Analysis Techniques . . . . . . . . . . . 10
    3.1.3 Subsidence Measurements . . . . . . . . . . . . . . 12

  3.2 Wildlife Studies . . . . . . . . . . . . . . . . . . . 12

    3.2.1 Small Mammal Trapping Techniques . . . . . . . . . . 12

      3.2.1.1 Summer 1976 . . . . . . . . . . . . . . . . . . 12
      3.2.1.2 Summer 1977 . . . . . . . . . . . . . . . . . . 14

    3.2.2 Vole Food Preference Tests . . . . . . . . . . . . . 17
    3.2.3 Wildlife Track Survey . . . . . . . . . . . . . . . 18

  3.3 Snow Measurements . . . . . . . . . . . . . . . . . . . 18

4. Results and Discussion . . . . . . . . . . . . . . . . . . 19

  4.1 Description of Major Habitats . . . . . . . . . . . . . 19

    4.1.1 Open Spruce-Lichen Forest . . . . . . . . . . . . . 19
    4.1.2 Lake Shoreline . . . . . . . . . . . . . . . . . . . 21
    4.1.3 Pond and River Margins . . . . . . . . . . . . . . . 23
    4.1.4 Fens and Bogs . . . . . . . . . . . . . . . . . . . 23
    4.1.5 Lichen Heath . . . . . . . . . . . . . . . . . . . . 26
    4.1.6 Crowberry Heath . . . . . . . . . . . . . . . . . . 26
    4.1.7 Natural Subsidence . . . . . . . . . . . . . . . . . 28

Page

4.1 Description of Major Habitats (continued) . . . . . . . . .

4.1.8 Disturbed Sites . . . . . . . . . . . . . . . . . 28

4.1.8.1 Oil Drilling Site . . . . . . . . . . . . . 28
4.1.8.2 Track Vehicle Trails . . . . . . . . . . 30
4.1.8.3 Native Camps . . . . . . . . . . . . . . 30
4.1.8.4 Seismic Lines . . . . . . . . . . . . . . 30

4.2 Description of Habitats on the Mark-Recapture Plot . . . . 35

4.3 Results of Vegetation Studies . . . . . . . . . . . . . 37

4.3.1 Effects of Seismic Activity on Vegetation . . . . 37
4.3.2 Species Richness On and Off Seismic Lines . . . . 39
4.3.3 Thermokarst and Erosional Subsidence along Seismic Lines . . . . . . . . . . . . . . . 42

4.4 Results of Small Mammal Studies . . . . . . . . . . . . . 42

4.4.1 Small Mammal Populations . . . . . . . . . . . . . 42
4.4.2 Vole Food Preference Tests . . . . . . . . . . . . 45
4.4.3 Vole Home Ranges . . . . . . . . . . . . . . . . . 55
4.4.4 Effects of Cut Lines on Small Mammals . . . . . . 63
4.4.5 Habitat Utilization by Red-Backed Voles on the Mark-Recapture Plot . . . . . . . . . . . . 65

4.5 Snow Conditions during April and May 1977 . . . . . . . . 65

4.6 Results of Winter Track Survey and Reactions of Wildlife to Seismic Lines . . . . . . . . . . 72

4.6.1 Willow Ptarmigan . . . . . . . . . . . . . . . . . 72
4.6.2 Voles and Lemmings . . . . . . . . . . . . . . . . 76
4.6.3 Red Squirrel . . . . . . . . . . . . . . . . . . . 76
4.6.4 Snowshoe Hare . . . . . . . . . . . . . . . . . . 79
4.6.5 Moose . . . . . . . . . . . . . . . . . . . . . . 79
4.6.6 Caribou . . . . . . . . . . . . . . . . . . . . . 79
4.6.7 Short-Tailed Weasel . . . . . . . . . . . . . . . 87
4.6.8 Mink . . . . . . . . . . . . . . . . . . . . . . . 87
4.6.9 Marten . . . . . . . . . . . . . . . . . . . . . . 87
4.6.10 Wolverine . . . . . . . . . . . . . . . . . . . . 88
4.6.11 Arctic and Red Foxes . . . . . . . . . . . . . . 88
4.6.12 Wolf . . . . . . . . . . . . . . . . . . . . . . . 88
4.6.13 Other Fur-Bearers . . . . . . . . . . . . . . . . 89

4.7 Usefulness of Seismic Lines to Trappers and Hunters . . . 89

5. Literature Cited . . . . . . . . . . . . . . . . . . . . . 92

Page

6. Appendices . . . . . . . . . . . . . . . . . . . . . . . . . 99

    6.1 Vascular Plants Recorded in the Vicinity of Aubry Lake, N.W.T. . . . . . . . . . . . . . . . . . . 99
    6.2 Lichens Collected in the Vicinity of Aubry Lake, N.W.T. . 99
    6.3 List of Bryophytes Collected at Aubry Lake, N.W.T. . . . . 110
    6.4 Botanical Description of Traplines . . . . . . . . . . . . 111

7. Acknowledgements . . . . . . . . . . . . . . . . . . . . . . 114

8. Postscript . . . . . . . . . . . . . . . . . . . . . . . . . 114

## LIST OF FIGURES

Page

1. Colville Lake village on the southeast shore of Colville Lake, 58 km north of the Arctic Circle . . . . . . 4

2. Map of the Aubry-Colville Lakes study area . . . . . . . . . . . 5

3. Map showing the study sites at the north end of Aubry Lake . . 6

4. Map showing the study sites at the south end of Aubry Lake . . 7

5. A plumb reading being taken along a traverse line which crosses a 1969-cut seismic line . . . . . . . . . . . . 13

6. A brown lemming captured in a Museum Special trap . . . . . . 15

7. Small mammal mark-recapture study plot located near the north end of Aubry Lake at 67°36'N, 126°30'W . . . . 16

8. Open spruce-lichen forest at the north end of Aubry Lake . . . 20

9. Sand-and-cobble beach at the north end of Aubry Lake . . . . . 22

10. Pond margin surrounding a small shallow thermokarst pond near the north end of Aubry Lake . . . . . . . . . . . . . . . 24

11. Fen with open spruce-lichen forest in the background . . . . . 25

12. Small lichen heath on the edge of Aubry Lake . . . . . . . . . 27

13. Crowberry heath on an exposed esker at the north end of Aubry Lake . . . . . . . . . . . . . . . . 27

14. A natural thermokarst landslip along the north shore of Aubry Lake . . . . . . . . . . . . . 29

15. Aerial view looking southeast along bulldozer supply trails leading to Mobile-Colville E-15 drilling site at the south end of Aubry Lake . . . . . . . . . . . . . . . . 31

16. Native fishing camp at the south end of Aubry Lake . . . . . . 31

17. Looking east along seismic line 11 at the south end of Aubry Lake . . . . . . . . . . . . . . . . 32

18. Thermokarst pool on a seismic line cut in 1969 near the south end of Aubry Lake . . . . . . . . . . . . . . . 33

Page

19. Seismic line cut in 1969 on the south slope of Colville Ridge . . . . . . . . . . . . . . . . . . . . . . . 34

20. Seismic line at the north end of Aubry Lake cut in March 1975 . . . . . . . . . . . . . . . . . . . . . . . 36

21. Density of trees and shrubs on various-age seismic lines and in adjacent open spruce-lichen forest . . . . . . . . . . . 38

22. Comparison of percent cover of various strata of vegetation in the open spruce-lichen forest and on seismic lines at the north and south ends of Aubry Lake . . . . . . . . . . 41

23. Average number of plant species per quadrat in various habitats and on seismic lines . . . . . . . . . . . 43

24. Thermokarst subsidence measurements taken along four traverse lines crossing supply trails leading to the Mobile-Colville E-15 drill site . . . . . . . . 44

25. The largest home range of an adult male red-backed vole on the Aubry Lake plot between 15 July and 5 August 1976 . . . 58

26. The largest home range of a juvenile red-backed vole on the Aubry Lake plot between 15 July and 5 August 1976 . . . 59

27. Home ranges of the 11 adult male red-backed voles captured at three or more trap stations between 15 July and 5 August 1976 on the Aubry Lake plot . . . 60

28. Home ranges of the ten adult female red-backed voles captured at three or more trap stations between 15 July and 5 August 1976 on the Aubry Lake plot . . . 61

29. Aubry Lake mark-recapture plot showing the total number of small mammal captures at each trap station . . . . . . . . 64

30. Hardness measurements being taken at a snow station along a seismic line . . . . . . . . . . . . . . . . . . . 68

31. Snow accumulation in the spruce-lichen forest in the Aubry-Colville area varied from 60 to 120 cm in April 1977 . . . . . . . . . . . . . . . . . . . . . . . . 69

32. Heavy qali (snow which accumulates in trees) loads on white spruce . . . . . . . . . . . . . . . . . . . . . . . . 71

33. Reactions of wildlife to seismic lines in the Aubry-Colville Lakes region during April and May 1977 . 74

Page

34. Sign of ptarmigan feeding on exposed willow buds . . . . . . . 77

35. Openings of ventilation shafts in a small sedge swale . . . . 78

36. Red squirrel tracks crossing a seismic line at right angles . 80

37. Members of the Bluenose caribou herd loafing along the east shore of Aubry Lake in April 1977 . . . . . . . 81

38. Caribou feeding sign along the shoreline of Aubry Lake, April 1977 . . . . . . . . . . . . . . . . . . . . . . . . 83

39. A trail made by 400 caribou which were observed moving up the north arm of Aubry Lake on 20 April 1977 . . . . 84

40. Sign of 40 caribou on an east-west seismic line which they followed for at least 16 km and perhaps for more than 32 km . . . . . . . . . . . . . . . . . . 86

41. A seismic line cutting through hilly, forested topography at the south end of Aubry Lake, April 1977 . . . . . . . . . . 90

## LIST OF TABLES

Page

1. Importance values of the tree and shrub strata on seismic lines and adjacent open spruce-lichen forest . . . . 40

2. Results of exploratory traplines set at the north end of Aubry Lake in 1976 . . . . . . . . . . 46

3. Summary of small mammal kill trapping on and off seismic lines at Aubry Lake in summer 1976 . . . . . 47

4. Summary of small mammal kill trapping on and off seismic lines at Aubry Lake in summer 1977 . . . . . 48

5. Vole food preferences as determined by cafeteria feeding trials . . . . . . . . . . . . . . . . . . . 49

6. Minimum area home ranges of red-backed voles on the Aubry Lake plot, 15 July to 5 August 1976 . . . . . . . 57

7. Snow station data collected in the Aubry-Colville Lakes area, 10 April to 1 May 1977 . . . 66

8. Mean values for snow data collected at snow stations on seismic lines and at bush sites in the Aubry-Colville Lakes area, 10 to 15 April 1977 . . . . . 70

9. Mean snow depths at varying distances from the shoreline of Aubry Lake, 1 May 1977 . . . . . . . . . . 73

## 1. SUMMARY

The objective of this study was to determine if and how the distribution and movement of game and fur-bearing animals are affected by seismic lines. As a corollary, the study was to ascertain to what extent seismic lines are used by trapper-hunters in preference to traditional routes. In order to obtain this information, it was necessary to first examine the effects of seismic lines upon the vegetation and small mammals which support the game and fur.

This study was conducted in the vicinity of Aubry and Colville Lakes, N.W.T. (study area encompassed 4,477 km$^2$) during three periods: 27 May to 31 August 1976, 7 April to 10 May 1977 and 1 to 24 August 1977. The open spruce-lichen forest is the dominant habitat in the region. Less extensive terrestrial habitats include lake shorelines, river and pond margins, bogs and fens, lichen heaths, crowberry heaths and thermokarst landslips. These natural habitats have been altered by seismic lines cut between 1969 and 1975, by several bulldozer supply trails, by an abandoned drilling site and by several temporary and permanent native campsites.

Seismic lines of various ages displayed different patterns of thermokarst subsidence and vegetation. Lines cut in 1969 have slumped an average of 34.2 cm below the adjacent undisturbed surface. Herbs, half-shrubs and grassy plants dominate these older lines. Seismic lines cut in 1975 showed far less evidence of thermokarst action; this is probably due to the use of protective "mushroom shoes" on the bulldozer blades. These newer lines are covered primarily with detritus, trees, shrubs, herbs and half-shrubs, while grassy plants are comparatively unimportant.

The red-backed vole is the most common small mammal in the area; in 24,192 trap-nights (using kill and live traps) 809 red-backed voles were captured, whereas only 45 meadow voles, 39 chestnut-cheeked voles, 22 masked shrews and 17 brown lemmings were taken.

From cafeteria feeding tests it was determined that red-backed voles possess a marked preference for fruits and flowers and that they reject stems, leaves and roots. Most of the preferred plants thrive along the margins of rivers and ponds, along shorelines or in moist disturbed areas such as seismic lines. The red-backed voles, however, tend to avoid these wet habitats and more frequently utilize the spruce-lichen forests. There were only 1/4 as many red-backed voles captured on seismic lines as were taken in the adjacent bush. Even though the voles generally avoid seismic lines, they will cross them to get from one part of their home range to another. Red-backed voles displaced by seismic lines are occasionally replaced by meadow voles along the older lines where moist grassy habitats develop in thermokarst slumps. During this study, however, the meadow voles never surpassed the number of red-backed voles displaced. Thus, it appears that seismic lines add habitat diversity to the predominant spruce-lichen forest but they are, nonetheless, detrimental to the production of voles. The density of seismic lines in the study area is

such that the decline in vole biomass is probably less than 0.05%.

During the spring field study, wildlife reacted to the seismic lines in varying ways. Willow ptarmigan appeared to be indifferent to the seismic lines unless there were exposed willows on the lines; in such cases the birds did not hesitate to feed on the lines. Ptarmigan reacted to other exposed areas, such as along rivers and lakes, in the same manner. Voles, red squirrels and snowshoe hares tended to avoid the seismic lines. Wolves, red foxes and arctic foxes occasionally utilized the seismic lines as travel routes. Mink never used the seismic lines, marten rarely followed them but weasels occasionally hunted along the lines. There was no sign of beaver, otter or muskrat utilizing the lines, and there was insufficient sign of wolverine to determine their reaction to the lines. Moose did not make use of the lines. Caribou, on the other hand, exhibited a moderate tendency to utilize the seismic lines as travel routes when snow conditions and orientation of the lines were relatively suitable to the direction of their migration. Whether this behaviour would have any significant effect in diverting migrations from normal routes is not known. My observations indicate, however, that lakes and water systems are more important to caribou as travel routes than are seismic lines.

From discussions with the Colville Lake trapper-hunters and from observations of their bush trails, it is clear that they are aware of the relatively lower productivity of fur and game on the seismic lines and that they do not bother to trap along these lines. Even if the productivity was as high on the seismic lines as in the surrounding countryside, there is another reason for the people to avoid these lines. Seismic lines slash through the land in an indiscriminant fashion, and, where the lines cut through hilly country, it is far more difficult to traverse the steep inclines on the seismic lines than it is to follow the natural topographic corridors such as lakes, ponds, rivers and their valleys or even the contour lines through the bush. This is especially true for the Colville people who use maneuverable dog teams rather than snowmobiles in the bush.

As of 1977 seismic lines covered approximately 632 ha or 0.18% of the land surface in the study area. I have seen no evidence that seismic lines in the area benefit the wildlife or the trapper-hunters of Colville Lake. On the other hand, I find it difficult to believe that the seismic lines, which represent such a small percentage of the land surface, have reduced the carrying capacity of the region for the fur-bearers or game animals. It is difficult, however, to predict what the accumulative effect would be upon the carrying capacity of the area (particularly for caribou) if additional seismic operations were conducted in the region.

# 2. INTRODUCTION

## 2.1 Objective

The objective of this study was to determine the effects of seismic lines upon the distribution and movements of fur-bearing mammals and terrestrial game species which in turn may affect the success of trapper-hunters operating in the vicinity of seismic lines. In order to obtain this information, it was necessary to first examine the effects of seismic lines upon the flora and small mammals which support the fur and game species.

## 2.2 Study Area

### 2.2.1 Study Sites and Field Operations

The Aubry-Colville Lakes area was chosen as the study site because:

(1) It is within the range of the Colville Lake Indians (Fig. 1) who are still actively engaged in trapping, particularly for marten (*Martes americana*) (Savishinsky, 1974).

(2) These lakes are surrounded by numerous seismic lines of differing ages and successional stages.

(3) The large bodies of water provide easy access to the seismic lines.

(4) Botanical and small mammal studies have never been conducted in this isolated area, and thus the data gathered provide additional scientific knowledge on this region.

The study area (Fig. 2) encompasses 4,477 $km^2$ of which about 25% is covered with water bodies while seismic lines cover approximately 632 ha or 0.18% of the land area.

Field studies were conducted during three periods: 27 May to 31 August 1976, 7 April to 10 May 1977 and 1 to 24 August 1977. During the first summer the field crew spent 308 person-days on Aubry Lake examining the flora and the small mammals in the vicinity of seismic lines (Figs. 3 and 4). The following spring 136 person-days were spent in the field examining the reactions of terrestrial game and fur-bearers to seismic lines by means of track surveys. An additional 65 person-days were spent during the second summer in continuing the small mammal studies.

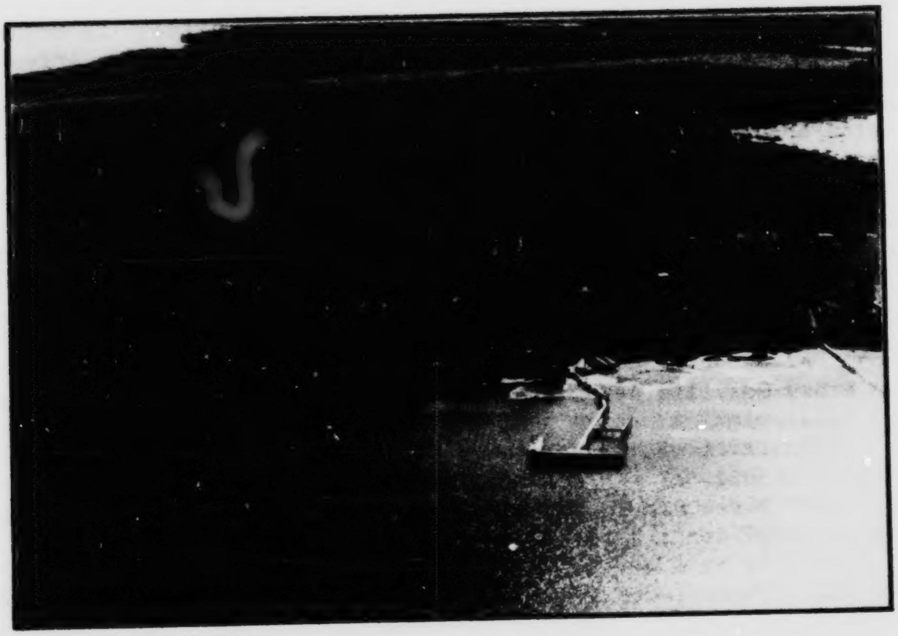

Fig. 1. Colville Lake village (67°10'N, 126°0'W) on the southeast shore of Colville Lake, 58 km north of the Arctic Circle.

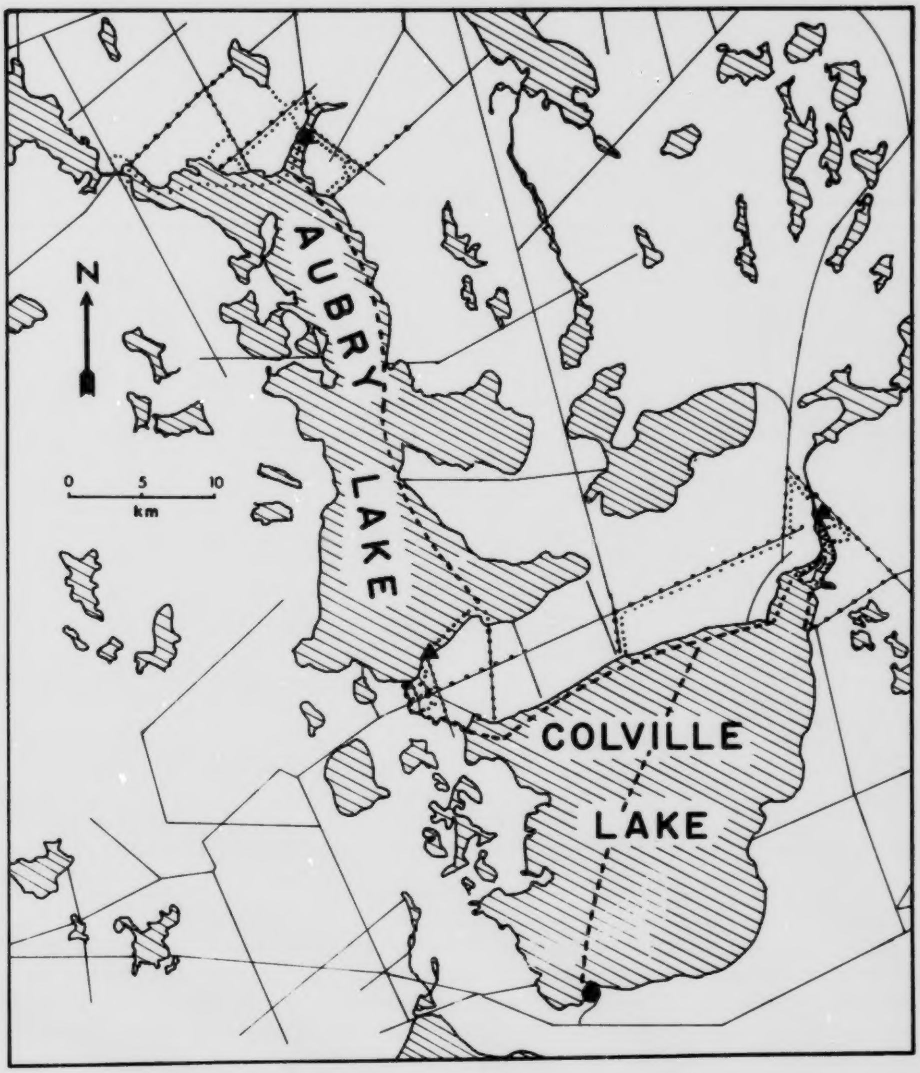

Fig. 2. Map of the Aubry-Colville Lakes study area (centre coordinates 67°20'N, 126°15'W). Straight lines represent seismic lines. Triangles indicate campsites used by the field crews. The circle at the south end of Colville Lake is the village of Colville Lake. Dotted lines represent the trails on and off the seismic lines which were surveyed for wildlife sign during April and May 1977. Dashed lines represent the field crew's other travel routes during this time.

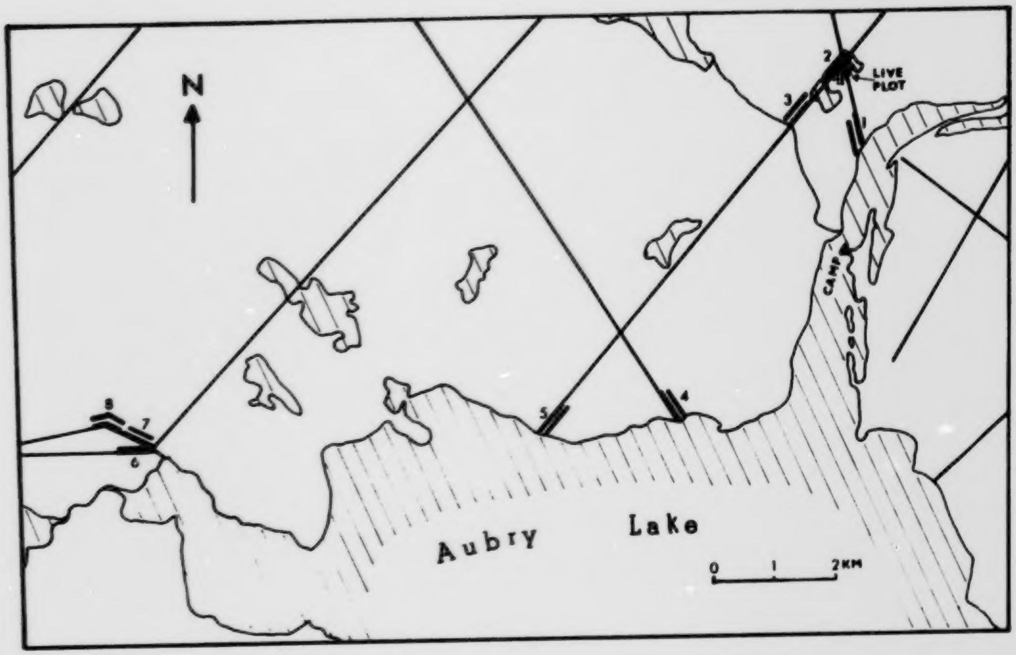
N
2
LIVE PLOT
3
1
CAMP
8
7
6
5
4
Aubry Lake
0 1 2KM

Fig. 3. Map showing the study sites at the north end of Aubry Lake. The triangle indicates the field camp. Straight lines represent seismic lines. Short heavy lines numbered 1 through 8 are the standard traplines on the seismic lines and the control traplines adjacent to the seismic lines. The live plot is the mark-recapture study plot used between 15 July and 5 August 1976.

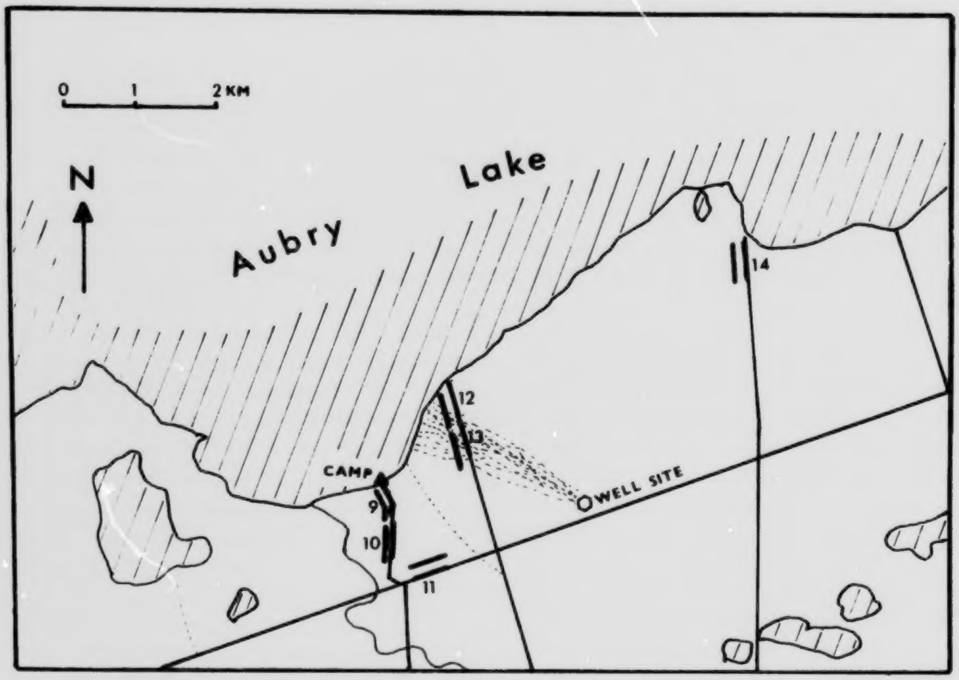
0
1
2 KM
N
Aubry Lake
14
12
13
CAMP
WELL SITE
9
10
11

Fig. 4. Map showing the study sites at the south end of Aubry Lake. Symbols are as in Fig. 3 with the addition of the well site (Mobile-Colville E-15) and bulldozer supply trails (dashed lines) leading from the shore to the well site.

### 2.2.2 Physiography of the Study Area

Aubry Lake (centre coordinates 67°25'N, 126°25'W), which lies approximately 85 km north of the Arctic Circle and 150 km northeast of Fort Good Hope, N.W.T., is situated in the northern part of the Colville Hills subdivision of the Interior Plains province (Bostock, 1964). The Colville Hills subdivision is an upland with lake-filled depressions separated by rolling hills which form a net-like plan with meshes 15 km or more. The large lakes and lower-lying ground within the ridges are about 250 to 300 m ASL, while the serpentine ridges have summits which occasionally reach 650 m ASL. The upland is an area of Paleozoic sediments (Douglas *et al.*, 1973).

The tallest hill in the area, 617 m ASL, lies 25 km due west of Colville Lake. In the immediate vicinity of Aubry Lake, the most prominent hills are those at the south end of the lake in the Colville Ridge which rises to 406 m ASL. The Colville Ridge, which runs east-northeast, is tentatively interpreted by Cook and Aitken (1971) as an anticlinal ridge. The Aubry Lake area is heavily mantled with glacial sediments, and bedrock outcrops are exceedingly rare.

Aubry Lake is a deep oligotrophic lake fed by numerous small creeks draining from the surrounding bogs, ponds and small lakes. The lake is fed by only one notable stream 15 to 20 m wide from Canso Lake to the northwest of Aubry Lake. In turn, Aubry Lake provides only one notable stream draining into Colville Lake. Colville Lake, also an oligotrophic lake fed by small streams, is drained by a single river at its northeast end.

### 2.2.3 Climate of the Study Area

The Aubry-Colville Lakes region possesses a cold dry subarctic climate. According to the N.W.T. Department of Information, the yearly average temperature is -7.5°C; the July mean high and low rise to 22.9°C and 7.6°C, respectively, while the January mean high and low dip to -25.6°C and -34.4°C, respectively. The annual precipitation is only 266.7 mm, about half of which falls as rain (147.3 mm) and the remainder as snow (1,150.6 mm). There are about 360 hours of daylight from December through February, 1,000 hours from March through May, 2,100 hours from June through August and 1,400 hours from September through November.

### 2.2.4 Habitats in the Study Area

There are seven natural types of terrestrial habitats in the study area defined by the dominant vegetation. An eighth habitat category has been established to include all sites disturbed by human agents. For a complete listing of all vascular plants in each habitat type, see Appendix 6.1.

### 2.2.5 Wildlife in the Study Area

About twenty species of waterfowl migrate through the Aubry-Colville region; several species also nest but in smaller numbers. The more notable species which breed here include the common loon (*Gavia immer*), whistling swan (*Olor columbianus*), Canada goose (*Branta canadensis*), oldsquaw (*Clangula hyemalis*), scaup (*Aythya* spp.) and red-breasted merganser (*Mergus serrator*). There are only two upland game birds, the spruce grouse (*Canachites canadensis*) and willow ptarmigan (*Lagopus lagopus*); the former is relatively uncommon but ptarmigan are abundant, especially in the winter when large flocks migrate into the area.

Five species of small mammals were recorded from the Aubry Lake area: meadow vole (*Microtus pennsylvanicus*), chestnut-cheeked vole (*M. xanthognathus*), red-backed vole (*Clethrionomys rutilus*), brown lemming (*Lemmus sibiricus*) and masked shrew (*Sorex cinereus*). Red-backed voles are by far the most common species present.

Snowshoe hares (*Lepus americanus*) were at a low point in their population cycle during this study. Red squirrels (*Tamiasciurus hudsonicus*) were also relatively uncommon; less than a dozen where noted during the two summers, but their sign was observed more frequently in the snow during the spring. Muskrat (*Ondatra zibethicus*) and beaver (*Castor canadensis*) are scarse in the area. The shores of Aubry and Colville Lakes, which for the most part are composed of coarse-grain sand, gravel or boulders, provide little habitat for muskrat and beaver. The smaller ponds and streams provide far more suitable habitat for these aquatic fur-bearers, but even here they are uncommon. Marten, mink (*Mustela vison*), short-tailed weasel (*M. erminea*), red fox (*Vulpes vulpes*) and black bear (*Ursus americanus*) are the most common year-round fur-bearers. Arctic fox (*Alopex lagopus*) occasionally invade this region in large numbers during the winter; the winter of 1976-77 was one of those winters. Lynx (*Lynx canadensis*), otter (*Lontra canadensis*), wolverine (*Gulo gulo*) and grizzly bear (*Ursus arctos*) are comparatively rare or uncommon. Wolves (*Canis lupus*) occupy the region; their sign is particularly evident when they associate with the Bluenose caribou (*Rangifer tarandus*) herd which overwinters in the Aubry-Colville area. Compared to the thousands of caribou which overwinter in the area, moose (*Alces alces*) are definitely uncommon.

# 3. METHODS

## 3.1 Floral and Disturbance Studies

### 3.1.1 Botanical Collections

An extensive collection of vascular plants (449 specimens; Appendix 6.1) and lichens (200 specimens; Appendix 6.2) was made. Representative mosses (45 specimens; Appendix 6.3) were also collected.

Most of the vascular plants were identified by the field crew and verified by Gloria Keleher, Curator of the University of Manitoba Herbarium. Dr. George W. Argus of the National Museum of Canada identified the willows (*Salix* spp.). Voucher specimens of the vascular plants have been deposited in herbaria at the University of Manitoba, Arizona State University and the National Museum of Canada (*Salix* spp. only).

Lichens were identified by Janet Marsh. Voucher specimens have been retained at the herbaria at the University of Manitoba and Arizona State University. Mosses have been identified by Dr. Royce Longton at the University of Manitoba, and voucher specimens are available from that university.

### 3.1.2 Vegetative Analysis Techniques

The vegetation of seismic lines and open spruce-lichen forests was compared on 14 seismic lines and their adjacent undisturbed forested control areas in the Aubry Lake region. Sampling took place along the snap traplines used in the small mammal survey (see Section 3.2.1). Eight seismic lines and their controls were located at the north end of the lake (Fig. 3), while six lines and controls were studied at the south end (Fig. 4). Seismic lines 1 through 6 at the north end were cut in March 1975, lines 7 and 8 also at the north end in the winter of 1973-74 and lines 9 through 14 at the south end in the late winter and early spring of 1969.

Vegetative sampling of the shrubs and trees was accomplished by application of the point-quarter technique (Cottam and Curtis, 1956). This method was employed along the snap traplines both on the seismic lines and in the open spruce-lichen forest parallel and 100 m in from the seismic lines. Data obtained from these lines allow the determination of total density for all shrub and tree species. Also, the relative density, the relative dominance, the relative frequency and the importance value for each species was calculated using the following equations (Phillips, 1959):

Density or number of individuals/ha = 10,000/(average point-to-plant distance)$^2$

Relative density = number of individuals of the species x 100/number of individuals of all species

Relative dominance = total areal coverage of the species x 100/total areal coverage of all species

Relative frequency = number of points of occurrence of the species x 100/number of points of occurrence of all species

Importance value = relative density + relative dominance + relative frequency

The line intercept method of determining cover (Canfield, 1941) was employed to sample the half-shrub and ground-layer vegetation. This method was applied at regular intervals of 21 m along the traplines and in the small mammal study plot (see Section 3.2.1). On the lines at the north end of Aubry Lake, a line transect 3 m in length was extended, and the species and extent of those individuals which were under- and over-lying the tape were recorded. The length of the tape covering detritus (earth, rocks and debris) was measured. At the south end of Aubry Lake, a 10-m line transect was laid across the seismic line so that the midpoint of the tape measure coincided with the midpoint of the seismic line. Transect lines were determined at 100-m intervals along the snap traplines. The individual species and plant cover data above and below the tape were determined and recorded.

Line transects were used to sample percentage cover of the individual species of half-shrubs and ground vegetation rather than quadrats since the vegetative cover in some areas was very dense, especially the shrubby species such as alder (*Alnus crispa*), Labrador tea (*Ledum* spp.), willow (*Salix* spp.) and blueberry (*Vaccinium uliginosum*). Measuring cover and counting individuals under these circumstances would have been extremely difficult.

In addition, quadrats 3 m$^2$ in size were placed on one side of the line transects at the sites on the north end of Aubry Lake and on seismic lines 9 and 10 at the south end. All species present in each quadrat were recorded and ranked on a total estimate scale of cover and abundance according to the system of Braun-Blanquet (1932). Presence-absence data of the plant species in various habitats were obtained from these quadrats as well as importance values calculated by summing the ranked values for each species in each specific habitat and dividing this result by the total number of quadrats in each habitat in which the species occurred.

Density of white spruce (*Picea glauca*) was determined in the open spruce-lichen forest on the small mammal study plot by sampling 19 10-m$^2$

quadrats (Phillips, 1959). All individuals over 1.37 m in height were counted in each quadrat, and 90 trees of large and small circumferences were cored to determine the approximate age of the stand.

### 3.1.3 Subsidence Measurements

In conjunction with the botanical study, measurements were taken on thermokarst and erosional subsidence along the seismic lines and the bulldozer supply trails cut in late winter and early spring of 1969 on the south end of Aubry Lake (Fig. 4). Eighty traverse lines of 14 to 42 m in length were run perpendicular to the seismic lines at regular 50-m intervals; these traverse lines were laid across the seismic lines along snap traplines 9 through 14. Four additional traverse lines were run perpendicular to the Cat trails. All traverse lines extended from undisturbed habitat, across berm and cut lines and on into undisturbed habitat on the other side of the lines. Plumb readings were taken along the traverse lines at 1-m intervals (Fig. 5). The widths of the undisturbed, cut line and berm portions of the traverse lines were noted. The subsidence measurements taken over each of these three ground conditions were averaged for each set of traverse lines crossing a seismic line or supply trail. The average figures, in turn, were used to calculate the average subsidence along each line.

## 3.2 Wildlife Studies

### 3.2.1 Small Mammal Trapping Techniques

#### 3.2.1.1 Summer 1976

In order to determine the effects seismic lines have upon small mammal populations, 14 standardized traplines were established along the various-age seismic lines. These traplines were designated lines 1A through 14A. Control traplines were set in undisturbed habitats about 100 m to one side of the seismic lines; the control lines were designated lines 1B through 14B. For the locations and botanical descriptions of these traplines, see Figs. 3 and 4 and Appendix 6.4. Both A and B traplines were 500 m in length and had 70 Museum Special snap traps at 7-m intervals. A mixture of peanut butter, chopped raisins, bacon grease and rolled oats was used as bait. Each trapline was set for six nights and checked daily. Thus, each A and B trapline was used for 840 trap nights (TN), giving a total of 11,760 TN for the 14 lines and their controls.

Fig. 5. A plumb reading being taken along a traverse line which crosses a 1969-cut seismic line.

A total of 268 small mammals were collected from the 14 standard traplines and their controls (Fig. 6). The following data were obtained from each specimen: species, sex, breeding condition, age, weight, location and date. All skulls were preserved but only half of the skins were prepared as museum specimens. The skulls and skins have been deposited in the collection of the Manitoba Museum of Man and Nature in Winnipeg.

In order to gain information on the effects of seismic lines on small mammal home ranges and movements, a live-trapping programme was initiated; this mark-recapture programme was conducted from 15 July to 5 August 1976 on a 14-m x 14-m grid plot established near the north end of Aubry Lake (see Fig. 3). The plot was situated on an open white spruce-lichen forest at the edge of a small thermokarst pond. Two seismic lines, cut in March 1975, crossed one another on the plot (Fig. 7). The plot originally had 19 columns with 10 rows of trapping stations in each and covered 2.85 ha. It was soon obvious that most of the voles were being captured at least a few times on the periphery of this plot, indicating that their home ranges most likely extended beyond the plot. In hopes of completely encompassing at least some of the voles' home ranges, the plot was extended on 26 July by three rows of all sides except the one bordering the pond. From 26 July to 5 August traps were set on these outer three rows as well as along the entire lengths of the seismic lines on the plot, thus covering a total of 5.57 ha.

After the plot was closed, 38 live traps were placed within 30 m of the outside edge of the plot for two nights in order to catch voles for the cafeteria feeding trials. Three marked voles from the plot were captured in these traps; these sites have also been used in calculating the voles' home ranges.

During the 21-day trapping period on the plot, 168 Sherman folding aluminum live traps (7.5 cm x 7.5 cm x 22.5 cm) were set for a total of 3,528 TN. Each trap was baited with the snap trap bait plus a few slices of dried apple. The traps were furnished with Terylene fibre for nesting material. The traps were either placed in the shade or covered with moss or lichen. Traps were checked twice daily. A total of 99 small mammals were captured on the plot. Every animal was toe-clipped and released at the capture site. The following data were recorded each time an animal was captured: toe-clip identification number, species, sex, breeding condition, age (adult or juvenile), capture site, date and time of day.

Exploratory traplines employing both kill and live traps were set for an additional 1,344 TN in various habitats while searching for small mammal populations; 42 small mammals were captured with this effort. These specimens were preserved in the same manner as those taken on the standard snap traplines.

#### 3.2.1.2 Summer 1977

In order to determine whether small mammals react in the same manner

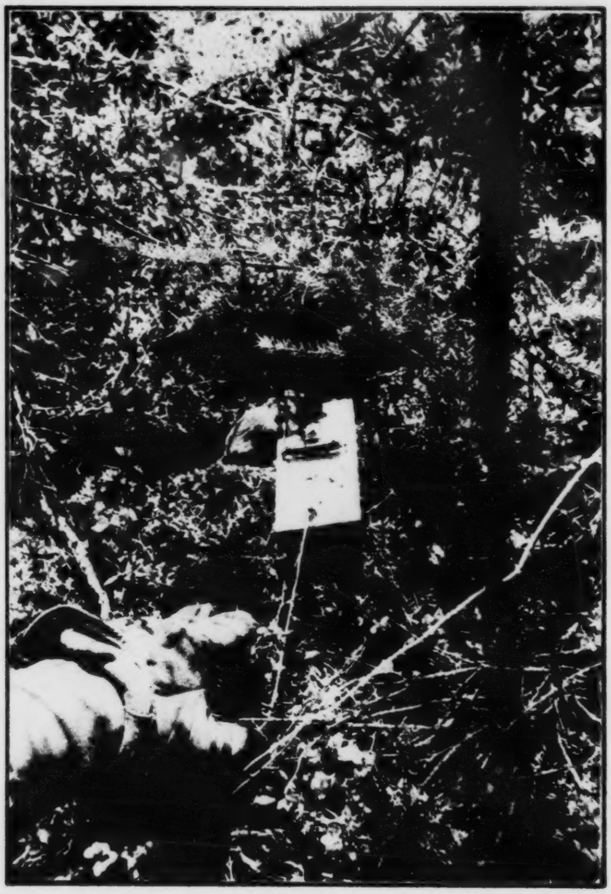

Fig. 6. A brown lemming captured in a Museum Special trap. These traps were used on the standard traplines as well as on the exploratory kill traplines.

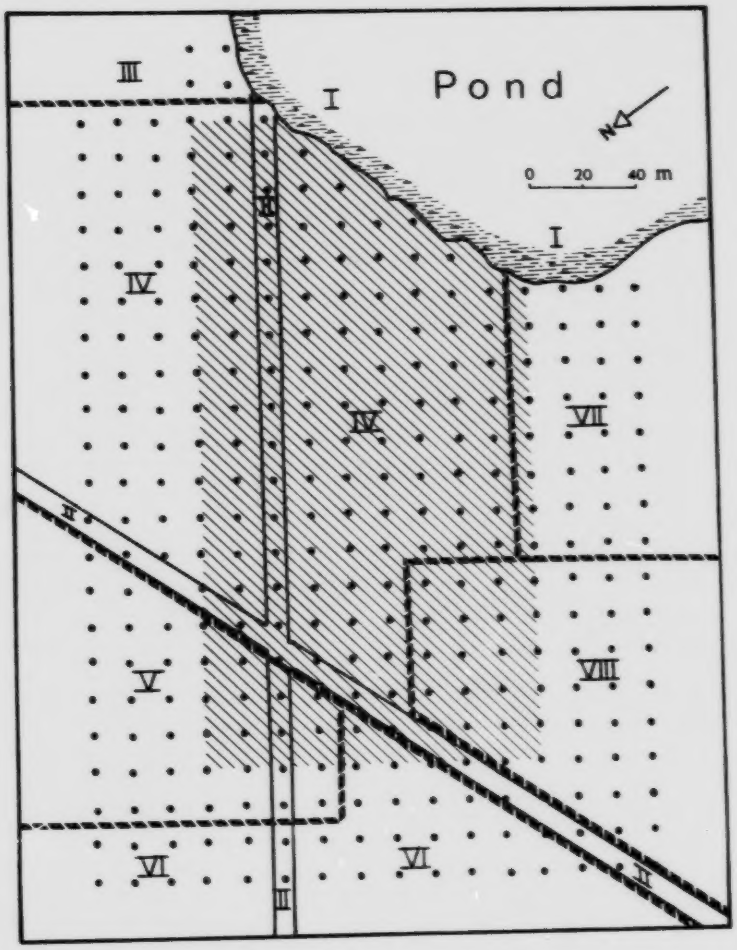

Fig. 7. Small mammal mark-recapture study plot located near the north end of Aubry Lake at 67°36'N, 126°30'W. The plot bordered a small thermokarst pond and was crossed by two seismic lines cut in March 1975. Each dot represents a trap station. The shaded area in the centre of the plot indicates the initial 2.85-ha plot utilized between 15 and 26 July 1976. The surrounding trap stations, which expanded the plot to 5.57 ha, were added on 26 July and were used until 5 August 1976. Trap stations along the seismic lines in the central shaded portion of the plot were used during both trapping periods. Numbered areas separated by dashed lines represent different vegetation zones (see Section 4.2).

to seismic lines during different phases of their population cycle, nine standard traplines were retrapped in 1977. Between 3 and 24 August 1977 traplines 1A and 1B through 6A and 6B at the north end of Aubry Lake and 9A and 9B through 11A and 11B at the south end were retrapped. The methods used were identical to those employed in 1976.

### 3.2.2 Vole Food Preference Tests

In order to ascertain which components of the local flora are important items in the voles' diets and to assist in analyzing their habitat requirements, cafeteria food tests were conducted following the techniques employed by Riewe (1973) and Thompson (1965). A majority of the vascular plants (97 of 175 species) recorded in the Aubry Lake vicinity, plus seven non-vascular plants, were offered to eight red-backed voles, two chestnut-cheeked voles and one meadow vole. A total of 72 tests were conducted between 29 July and 13 August 1976.

The voles were caged individually in wire-mesh cages measuring approximately 10 cm x 15 cm x 50 cm. Terylene fibre was provided for nesting material. Water in small bowls was supplied *ad libitum*. The cages were placed on tin foil in order to catch any food scraps that might fall out during the tests. The cages were maintained at ambient temperature in a well-vented tent. At the beginning of each test, 10 to 25 species of plants were placed in each cage. Dried apple, proven microtine bait (Riewe, 1971), was supplied in excess, thereby allowing the test animals to maintain themselves on apples if they so desired and allowing for the avoidance of unpalatable plants. The results of these cafeteria feeding trials thus indicate which plants were preferred by the voles rather than which plants might be consumed under dire circumstances.

Detailed records were kept on the plant species and the amount and parts given to each vole (*e.g., Vaccinium uliginosum*: 7 berries, 8 cm of roots, 95 leaves and 30 cm of branches). After 24 hours, the voles were removed from their cages, and the plants examined for feeding sign. After every test each anatomical plant part presented to the voles was assigned a preference value ranging from 0 to 3:

0 = plant part rejected by all voles

1 = plant part accepted very poorly (less than 25% consumed) by some voles and rejected by other voles

2 = variable acceptance; plant part accepted readily (75 to 100% consumed) by some voles while other voles either completely rejected or consumed less than 25%

3 = plant part readily consumed (51 to 100%) by all voles

### 3.2.3 Wildlife Track Survey

The track survey was conducted from a base camp at the northeast end of Colville Lake and from two outpost camps on Aubry Lake. During the 34 days of field work in April and May, a total of 1,362 km were traversed by snowshoes and snowmobiles. Weather conditions permitted track surveys to be made on only 15 days; it was impossible to conduct surveys on the remaining 19 days because of either overcast skies (hence poor lighting conditions), snow storms or slushy snow caused by temperatures of up to 19°C which provided support for neither snowshoes or snowmobiles.

Surveys were conducted along 72.3 km of seismic lines cut in 1969 and along 72.9 km of lines cut between 1973 and 1975. Control bush trails totalling 34.9 km were surveyed in the vicinity of the 1969 seismic lines and 39.8 km of control bush trails were surveyed near the seismic lines cut between 1973 and 1975. In addition, animal sign was recorded along 20.2 km of rivers and creeks and across 60.3 km of lakes. When surveying the seismic lines, all tracks were recorded which either crossed or followed along the 10-m wide lines. In order to have comparable results in the bush or on lakes and rivers, only those tracks which were within 5 m of either side of our trails were recorded. The majority of the lines were surveyed only once, but some were surveyed as many as four times. These lines and trails were surveyed a second, third or fourth time only after a snowfall had occurred and one or more snow-free days had elapsed; this allowed the wildlife sufficient time to leave enough sign to warrant another traverse along the line or trail. The seismic lines and their control bush trails were surveyed simultaneously by different members of the field crew in order to obtain comparable results.

## 3.3 Snow Measurements

Snow stations were established during the spring field activities according to procedures outlined in Klein *et al.* (1950). The snow kit used was a modified National Research Council of Canada kit. Snow investigations were intended to provide an accurate description of changing snow conditions that prevailed throughout the period 7 April to 10 May 1977. They were not intended to investigate specific differences in snow characteristics associated with seismic lines. However, certain peculiarities in the snow regime of the latter were noted and warrant further investigation as they appear to influence the movement behaviour of some animals.

# 4. RESULTS AND DISCUSSION

## 4.1 Description of Major Habitats

### 4.1.1 Open Spruce-Lichen Forest

White spruce forests (Fig. 8) with an understory of lichen mats and ericaceous shrubs predominate in the study area; approximately 60% of the land surface is covered with this plant community. According to Brown (1970), the area is located at the southern limit of continuous permafrost zone. Soil development was noted to vary between the different habitat types. In the spruce-lichen forest, the soils are mainly of organic material remaining moist throughout the summer.

Ground-layer vegetation reflects local environmental conditions. Lichen mats, primarily *Cladina alpestris*, *C. arbuscula*, *C. rangiferina* (reindeer lichen), *Cladonia amaurocraea*, *Cetraria cucullata* and *C. nivalis*, dominate the well-drained slopes of the forest. In drainage gulleys and other shaded moist areas, mosses usually replace the lichens. *Peltigera aphthosa*, a large foliose lichen, is found in association with feather mosses and Lapland cassiope (*Cassiope tetragona* ssp. *tetragona*), a half-shrub, in the wetter regions of the slopes. In shaded and moist areas and especially under shrub and spruce canopies, half-shrubs such as bearberry (*Arctostaphylos rubra*), avens (*Dryas integrifolia* ssp. *integrifolia*), crowberry (*Empetrum nigrum* ssp. *nigrum*) and lingonberry (*Vaccinium vitis-idaea* ssp. *minus*) are abundant. Forbs common among the lichen mats and moss clumps in some areas are sweet coltsfoot (*Petasites frigidus*), wintergreen (*Pyrola* spp.) and bog star (*Parnassia palustris* ssp. *neogaea*). The only areas in which grassy plants are significant in the open spruce-lichen forest are wet areas, resulting from forest floor disturbances such as animal runways and fallen trees. Sedges (*Carex* spp.) are more abundant than grasses.

Forest openings provide habitat for understory shrubs such as willows (*Salix arbusculoides*, *S. glauca*, *S. lanata* ssp. *richardsonii*) and shrub birch (*Betula glandulosa*) (Fig. 8). The ericaceous shrubs Labrador tea (*Ledum palustre* ssp. *groenlandicum*) and blueberry (*Vaccinium uliginosum*) are the dominant woody shrubs; the latter occupy most forest openings. Shrubs of lesser importance but common include shrubby cinquefoil (*Potentilla fruticosa*) and Lapland rosebay (*Rhododendron lapponicum*). A few stands of tamarack (*Larix laricina* var. *alaskensis*) were found at the south end of Aubry Lake situated in poorly drained areas of the spruce-lichen forest.

Forbs and half-shrubs, lichens and mosses comprise the most important strata in the spruce-lichen forest. None of the strata provide more than 20% of the cover, which indicates that this habitat type is not

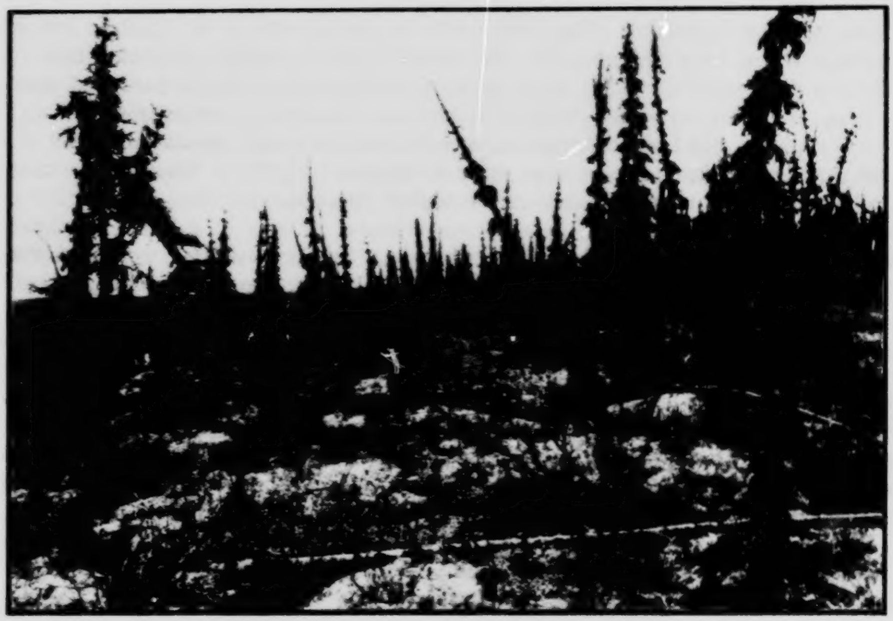

Fig. 8. Open spruce-lichen forest at the north end of Aubry Lake. The understory is dominated by shrub birch, blueberry and willows.

dominated by one particular stratum. Trees and shrubs cover 11% of the area sampled, but this figure may be low as the upper canopies are not included in the line transects from the north end of Aubry Lake.

Open spruce-lichen forests are inhabited by fairly large populations of red-backed voles which are the mainstay of marten and short-tailed weasels. In the moister areas with an understory of shrubs, the other species of small mammals augment the red-backed voles. The white spruce also provide food and shelter for red squirrels and spruce grouse as well as several passerine birds. It is the lichens and other ground cover which attract the Bluenose caribou herd to overwinter in this region. Naturally, all of the large carnivores occasionally use or traverse the spruce-lichen forest. Moose also utilize this habitat, but it is primarily the willow and alder patches scattered through the forests which are important to moose during the winter months. Snowshoe hares and ptarmigan are likewise supported by the willow patches.

### 4.1.2 Lake Shoreline

Lake shorelines (Fig. 9) which make up less than 5% of the land area are composed of two successional stages. Established shorelines support a cotton grass-sedge complex (*Eriophorum-Carex*) blending into an older band of willows and occasionally alders. *Boschniakia rossica*, a plant which is parasitic on alder roots, is found associated with the alders. Lichens and mosses are absent from the thickets because of litter accumulation from the deciduous alders. Sandy and rocky younger shorelines or those exposed to ice-pack abrasion in the spring support a sparse vegetative cover of various herbs which establish themselves in disturbed areas, for example, wormwood (*Artemisia Tilesii*), fireweed (*Epilobium angustifolium*), river beauty (*E. latifolium*) and fleabane (*Erigeron elatus*).

The short spike rush (*Eleocharis acicularis*) is especially abundant along lake shorelines with a great volume of decomposed organic material. Clumps of marsh fleabane (*Senecio congestus*) and mats of crowfoot (*Ranunculus confervoides*) and creeping spearwort (*R. repans*) are also common in these areas.

The cotton grass-sedge complex provides habitat for several ground-nesting birds, especially whistling swans, oldsquaws, lesser yellowlegs (*Totanus flavipes*) and tree sparrows (*Spizella arborea*) as well as for isolated populations of microtines. During the summer the shorelines are used as travel routes by moose and as travel and hunting routes by several predators, especially black bear and mink. The willows and alders provide important feeding areas for ptarmigan, hare and moose in the winter. These herbivores, in turn, attract weasels, mink, arctic and red foxes and wolves to the lake shorelines.

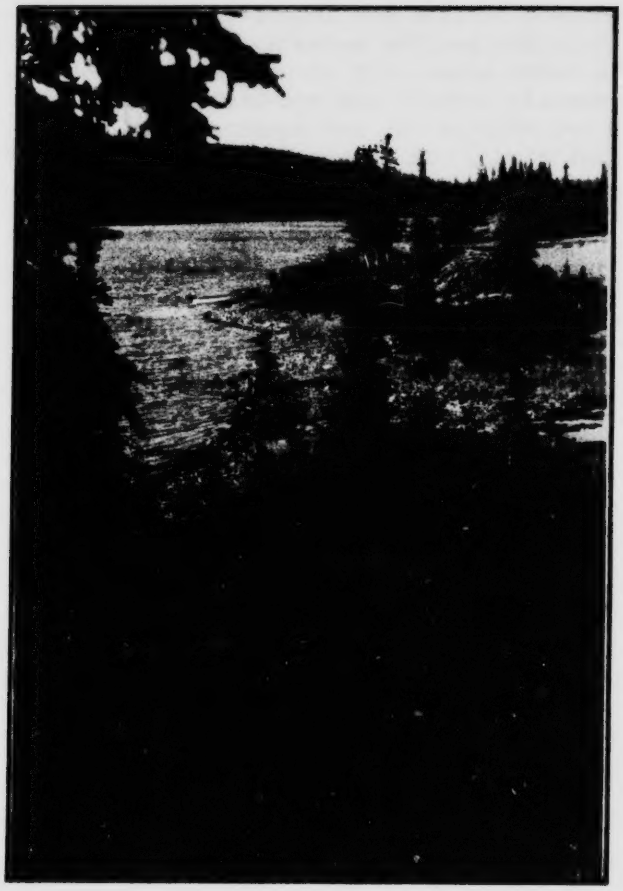

Fig. 9. Sand-and-cobble beach at the north end of Aubry Lake. Above the exposed beach, the cotton grass-sedge community blends into a narrow strip of alder and willow and then into the dominant open spruce-lichen forest.

### 4.1.3 Pond and River Margins

Pond and river margins (Fig. 10) are about 10 m wide and blend into the surrounding vegetation type, usually open spruce-lichen forest. The sedge *Carex aquatilis* is the most common species growing at the water's edge. Pockets of mare's tail (*Hippurus vulgaris*) are abundant in the shallows, and pondweeds (*Potamogeton* spp.), horsetail (*Equisetum fluviatile*), water lily (*Nuphar variegatum*) and marsh fivefinger (*Potentilla palustris*) are also common in the shallow water.

Wet humic ground just above the water level is most often occupied by northern water carpet (*Chrysosplenium tetrandrum*), willow herb (*Epilobium davuricum*), bedstraw (*Galium trifidum*), chickweed (*Stellaria crassifolia*) and sandwort (*Minuartia dawsonensis*). Mosses form a ground-cover mat underneath the sedges in most pond margins. The liverwort *Marchantia* sp. occupies shaded wet areas on humic soil.

Pond and river margins which are drying up support shrub birch, cassandra (*Chamaedaphne calyculata*), sweet gale (*Myrica gale*) and willow. Margins with a great amount of waterfowl feces support willow herb, cotton grass, willow (*Salix alaxensis*) and marsh fleabane. Mosses form an understory for sedges in wet areas. Lichens, on the other hand, are absent from this habitat type; fluctuating water levels will not permit these plants to become established.

Pond and river margins cover a relatively small percentage of the land area, probably less than 2%, but this habitat is considerably more important than it might appear. Moist sedge margins provide excellent habitat for populations of meadow voles and chestnut-cheeked voles as well as for several species of waterfowl and shorebirds. This habitat provides moose with summer feeding and loafing areas as well as food and shelter for muskrat and beaver. Mink, weasel, otter and fox hunt extensively along these pond and river margins.

### 4.1.4 Fens and Bogs

Fens (Fig. 11) are dominated by sedges (*Carex* spp. covered 37% of the fens sampled), whereas bogs are dominated by *Sphagnum* mosses. Both fens and bogs succeed ponds. Wetter bogs have a complete ground cover of moss (mosses covered 52% of the bogs sampled), and drier bogs are interspersed with *Sphagnum* hummocks. These hummocks have a definite flora of their own, principally shrubs and half-shrubs such as bog rosemary (*Andromeda polifolia*), cassandra, Labrador tea, cloudberry (*Rubus chamaemorus*), cranberry (*Oxycoccus microcarpus*), the willow *Salix arctophila*, lingonberry and the sedges *Carex capitata* and *C. limosa*. Lichens are virtually absent except for the white crustose species *Icmadophila ericetorum* which grows flat against the *Sphagnum* in small pockets on the hummock tops. Depressions between the hummocks mainly support sedges. Trees and shrubs (shrub birch and willows), sedges and

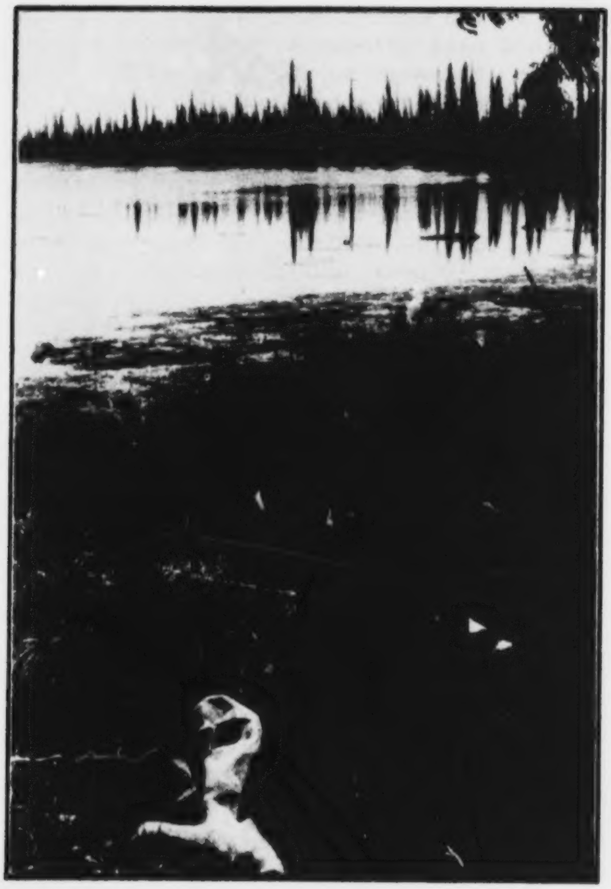

Fig. 10. Pond margin surrounding a small shallow thermokarst pond near the north end of Aubry Lake. The botanist and assistant are recording vegetation data from a 3-m x 3-m quadrat. The small mammal mark-recapture plot is located on the far side of this pond.

Fig. 11. Fen with open spruce-lichen forest in the background. Sedge tussocks and *Sphagnum* hummocks are common in this fen.

lichens each cover less than 10% of the raised *Sphagnum* hummocks.

The next successional stage after the hummocky stage is characterized by shrub birch and willows, provided the active layer of permafrost has increased in depth through litter accumulation and can support shrub growth.

Most fens and bogs near Aubry Lake are not very large, but there are extensive ones surrounding the shores of Colville Lake. These moist habitats cover approximately 10 to 15% of the study area. Open fens and bogs support little in the way of wildlife; however, closed fens with stunted spruce, willow and alder often possess comparatively dense microtine and shrew populations.

### 4.1.5 Lichen Heath

Lichen heaths (Fig. 12) are covered primarily by lichens (lichens covered 36% of the areas sampled). The dominant lichens are the yellow terricolous *Cladina* spp. of which *C. alpestris, C. arbuscula* and *Cladonia amaurocraea* are most abundant. *Cladina rangiferina, Cetraria cucullata, C. islandica* and *C. nivalis* are also profuse in the lichen associations. Ericaceous shrubs, especially Labrador tea, are second in importance to lichens and cover 30% of the heath areas; they are found between and on the sides of *Sphagnum* hummocks. Lingonberry is plentiful in the shade underneath the Labrador tea. Cloudberry is abundant on exposed hummock tops. Mosses of the cushion growth-form are found on shaded hummock sides. Solitary white spruce are standing relicts of previous fires.

Lichen heaths can develop into a shrub birch seral stage and thence to a mature spruce-lichen forest as evidenced in some of the areas surveyed. Other lichen heaths, especially in the more hummocky areas, are shallowly underlain with permafrost and tend to resist succession.

Lichen heath areas are scattered throughout the study area. They are neither very prevalent (they cover probably less than 5% of the area) nor are they very large. They are usually found on low-lying level ground, on a point of land or covering an exposed site. Lichen heaths are utilized by caribou bands in the winter, but most other wildlife species rarely use them.

### 4.1.6 Crowberry Heath

Crowberry heaths (Fig. 13) are open, sparsely vegetated areas dominated by mats of *Empetrum nigrum*. One of these barren areas is located on an esker at the north arm of Aubry Lake, and another such area is situated about 2 km south of the first. These Aubry Lake barrens are the result of fire a number of years ago. In the Mackenzie Delta

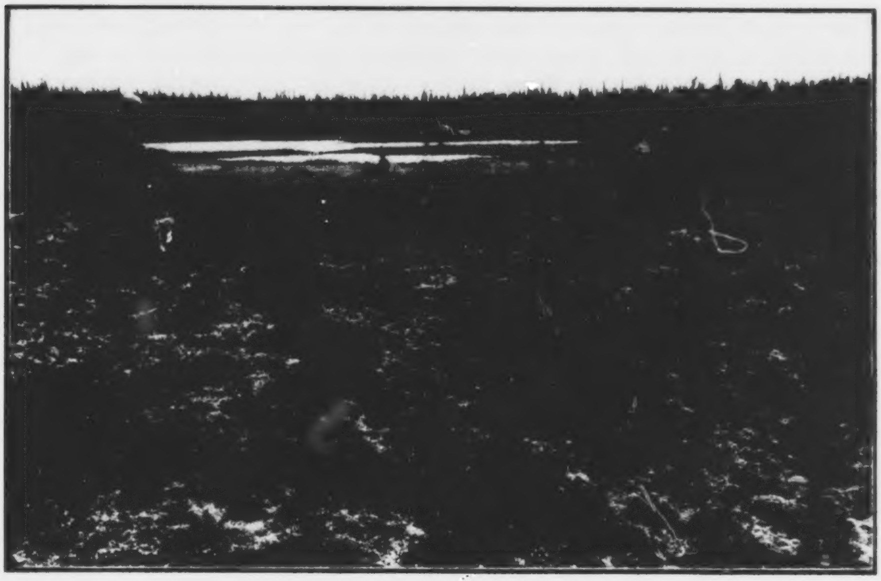

Fig. 12. Small lichen heath on the edge of Aubry Lake. This heath blends into a fen and open spruce-lichen forest in the background.

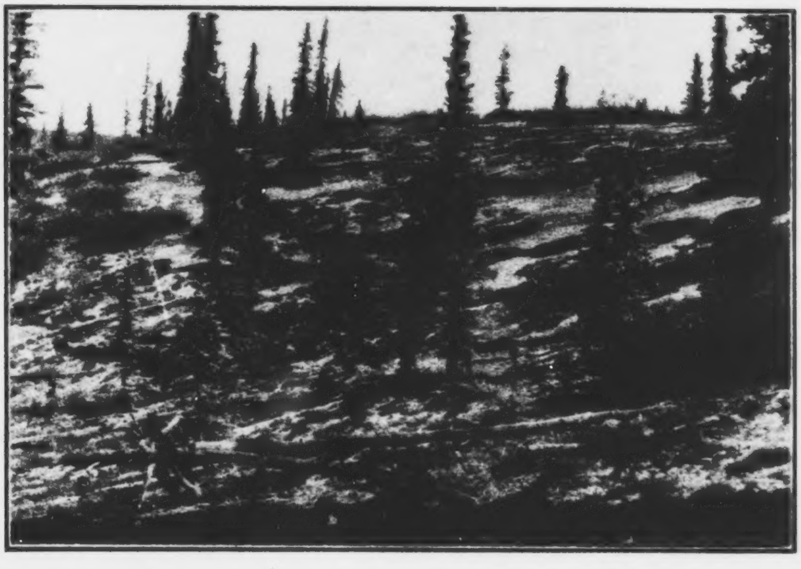

Fig. 13. Crowberry heath on an exposed esker at the north end of Aubry Lake. The remains of charred trees indicate this is a seral stage caused by fire.

area, according to Gill (1973), secondary succession of low Arctic tundra moss, lichen and heath species has taken place on extremely exposed sites that have been cleared of trees and shrubs; the northwest-facing crowberry barren noted above from Aubry Lake is an example of such an exposed site. Shrub birch and blueberry establish themselves in the more wind-protected areas of the barrens.

Crowberry heaths are quite small and cover considerably less than 1% of the study area. These small heaths show signs of winter caribou use but otherwise appear to be of little importance to wildlife.

### 4.1.7 Natural Subsidence

Mudflows, as described by Lambert (1972, 1976) tend to occur on sloping surfaces where the active layer is thick and where silt-rich soils with high ice content are overlain by peat. These thermokarst features often develop along shorelines where wave action or rafting ice erode away the vegetation exposing the substrate to greater heat penetration. Once the substrate thaws, the mud flows downhill. As the subsurface slumps it creates a massive scar with a headwall often extending several metres above the semicircular mudflow. Islands of vegetation are scattered throughout the mudflow. The secondary succession which takes place on these subsidences has been described by Lambert (1976). Along the shores of Aubry Lake where these mudflows are common (Fig. 14), wormwood, fireweed and marsh fleabane are important colonizers.

These natural thermokarst areas cover less than 1% of the study area and do not appear to be important to wildlife.

### 4.1.8 Disturbed Sites

#### 4.1.8.1 Oil Drilling Site

One abandoned oil drilling site (Mobile-Colville E-15) is located in the study area near the top of Colville Ridge at the south end of Aubry Lake. The oil well was spudded on 18 April 1970 and abandoned on 18 October of that same year. Several plant species are found only at this site growing in the gravelly soil; these species include yarrow (*Achillea sibirica*), goosefoot (*Chenopodium Berlandieri* ssp. *Zschackei*), pale corydalis (*Corydalis sempervirens*) and raspberry (*Rubus idaeus*). These species were probably introduced by track vehicles working at the drilling site.

Fig. 14. A natural thermokarst landslip along the north shore of Aubry Lake. Clumps of vegetation from the surrounding spruce-lichen forest are evident in the mud flow.

#### 4.1.8.2 Track Vehicle Trails

Trails were bulldozed through the open spruce-lichen forest during the late winter and early spring of 1969 to transport supplies to the oil drilling site at the south end of Aubry Lake (Fig. 15). It appears that these trails were haphazardly blazed with no planning whatsoever. Because the insulative ground layer was disturbed on these trails, thermokarst has occurred, causing considerable slumping in the middle of the trails. Spruce have had their roots undercut, and soil has washed away by downhill drainage and, particularly, spring runoff. The trees thus are leaning to one side. Lush growths of grasses, mainly reed bent grass (*Calamagrostis purpurascens*), are confined to these track trails.

#### 4.1.8.3 Native Camps

Native campsites of seasonal use are scattered throughout the study area. Winter camps are easily identified since the trees are chopped 0.5 to 1 m above ground level, corresponding to the snow accumulation in the forest at cutting time. Clearings in the spruce-lichen forest resulting from these camps have opened habitats for such shrubs as alder, shrub birch, willows, blueberry and various species of grasses.

Permanent fishing camps with cabins are located on the south shore of Aubry Lake (Fig. 16) and along the north shore of Colville Lake. Vegetation disturbance is great in the vicinity of the buildings and in places where dogs have been tethered. Fireweed flourishes especially where the dogs have been tied. Shrub birch has invaded areas where disturbance has been less over the past few years.

#### 4.1.8.4 Seismic Lines

Seismic lines of different ages show different characteristics regarding thermokarst subsidence and vegetation. The older lines, cut in 1969 and located at the south end of Aubry Lake, are reflexed toward their centres (see Section 4.3.3). The probable reason for this slumping on the older seismic lines is the fact that mushroom shoes were not used on the bulldozer blades for protection of the insulating ground layer. Grasses are abundant throughout the length of seismic lines where slumping has occurred (Fig. 17). Pond margin species such as northern water carpet, river beauty (*Epilobium latifolium*), marsh fleabane and chickweed are established in the wet humic soil. In addition, deep thermokarst pools are habitat for mats of crowfoot (Fig. 18). Tussocks of cotton grass flourish in the moist areas between the wet sections dominated by cotton grasses and the dry sections dominated by grasses. The moist-to-wet sites also support willows. Three to four year-old white spruce saplings are plentiful on the dry hillslopes of lines where thermokarst erosion has not occurred (Fig. 19).

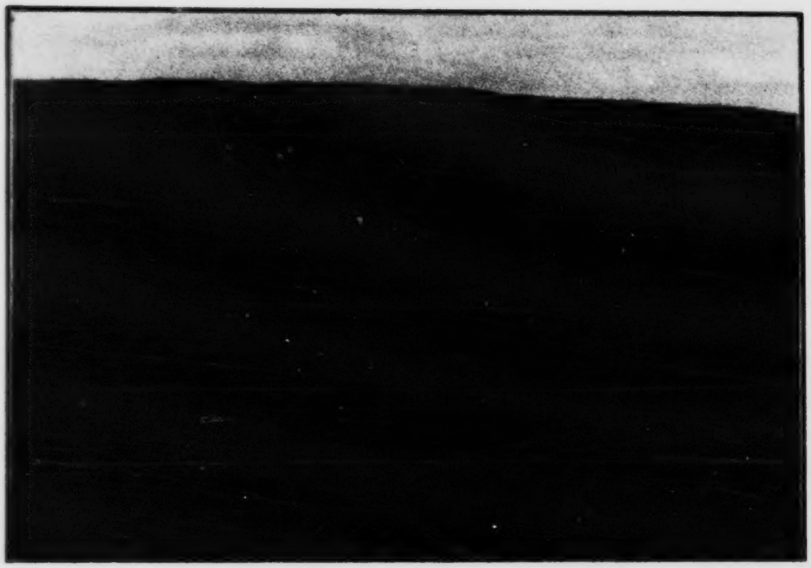

Fig. 15. Aerial view looking southeast along bulldozer supply trails leading to Mobile-Colville E-15 drilling site at the south end of Aubry Lake.

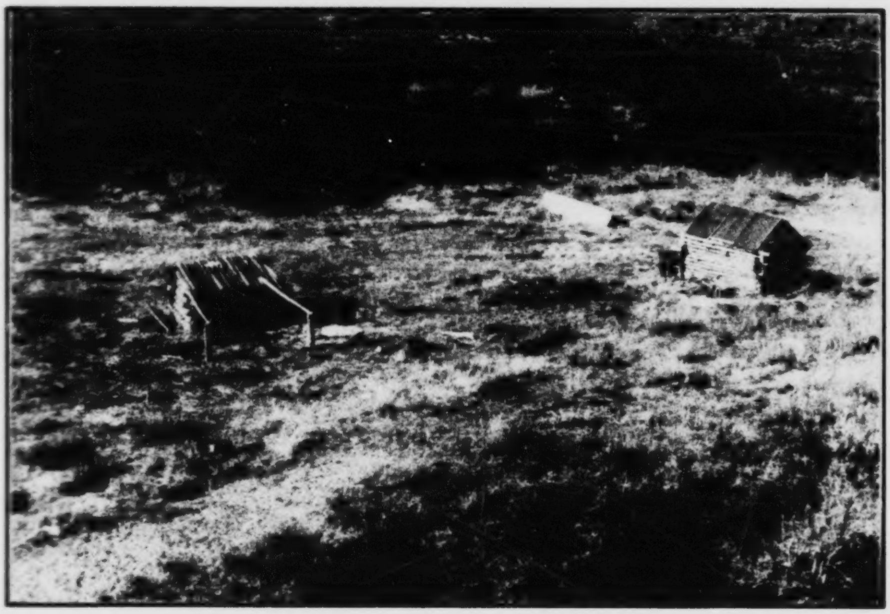

Fig. 16. Native fishing camp at the south end of Aubry Lake. This camp is used in autumn when white fish (*Coregonus clupeaformis*) migrate into the river draining Aubry Lake into Colville Lake.

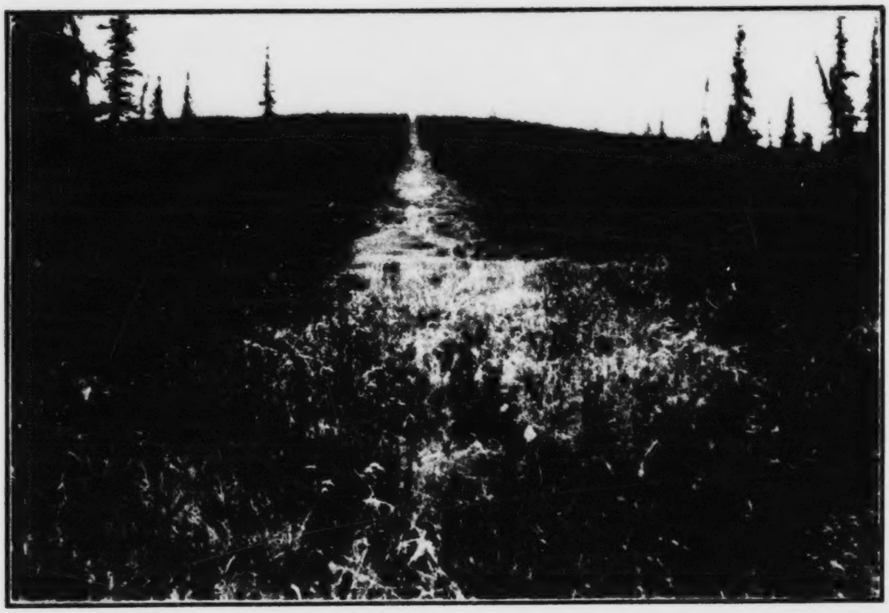

Fig. 17. Looking east along seismic line 11 at the south end of Aubry Lake. This 1969-cut line is now dominated by grasses, sedges, forbs and half-shrubs.

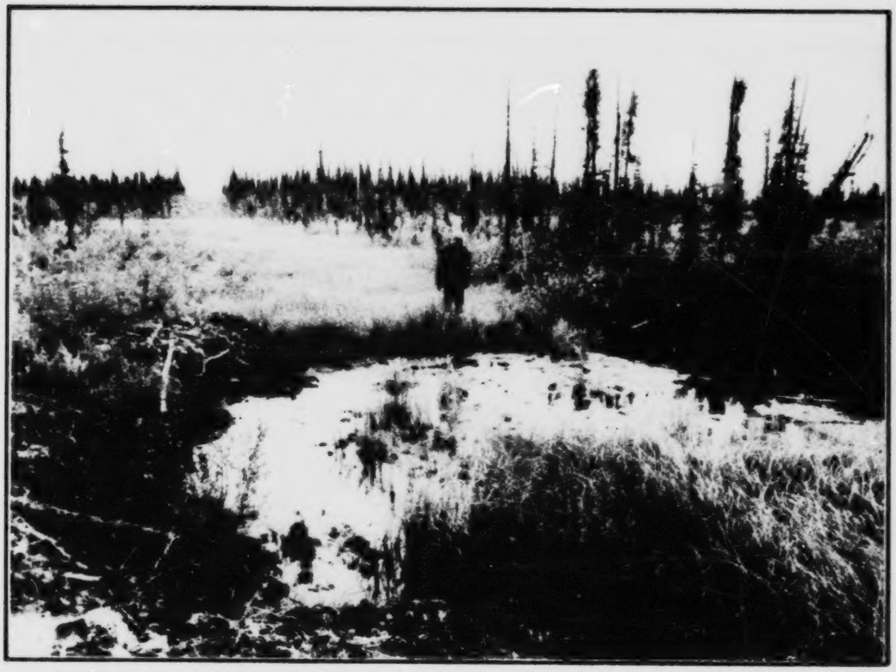

Fig. 18. Termokarst pool on a seismic line cut in 1969 near the south end of Aubry Lake. The line has been invaded by a lush growth of grasses and sedges. The pool provides habitat for bladderwort (*Utricularia intermedia*), mare's tail and crowfoot.

Fig. 19. Seismic line cut in 1969 on the south slope of Colville Ridge. This portion of the dry slope is dominated by shrub birch and willows.

The recent seismic lines cut in the spring of 1975 utilizing the mushroom shoes do not exhibit the successional trends evident in the older lines (Fig. 20). The only areas in which thermokarst is apparent are isolated pools where the insulative layer was inadvertently disturbed. The growth of willow sucker shoots is well-established on most recent seismic lines. The development of new shoots of the ericaceous shrubs Labrador tea, blueberry and Lapland rosebay is apparent. Flowering forbs are abundant in the spring and early summer on these lines. They tend to prefer the well-drained slopes rather than the level wet areas. The more abundant forbs are anemone (*Anemone parviflora*), gentian (*Gentiana propinqua*) and ragwort (*Senecio lugens*). Grasses and sedges are sparse on these younger seismic lines. Lichen and moss mats are somewhat damaged and in a secondary successional stage.

### 4.2 Description of Habitats on the Mark-Recapture Plot

Based on sampling of vegetation and age and density studies of white spruce stands, the mark-recapture plot is divided into eight areas (Fig. 7).

I. This area includes only the pond margin; see Section 4.1.3 for a description of this habitat.

II. This area includes the two seismic lines cut in March 1975; see Section 4.1.8.4 for a description.

III. This small area in the northeastern section of the plot contains the oldest average age trees (211 years), with an average density of 9 trees/10-m$^2$ quadrat. The percentage detritus accumulation of ground cover is low, also indicating a more mature forest stand. Lichens and mosses form the ground cover layer with species such as bearberry, dryas, crowberry and lingonberry. The shrub layer, which is usually identified with forest openings and younger forested areas, is virtually absent from this mature spruce stand.

IV. The largest habitat type on the plot occupies the central and northwestern areas. White spruce trees are of the smallest average circumference (13 cm) and the youngest average age (67 years). The average number of trees by 10-m$^2$ quadrat is 20, indicating an immature forest with many small-diameter trees. The soils of this area contain a greater amount of moisture, with *Sphagnum* moss being dominant. Shrub birch, dryas, horsetail (*Equisetum scirpoides*) and willows are abundant throughout the area.

V. This area, located in the northwestern section of the plot, is characterized by having the least average number of trees

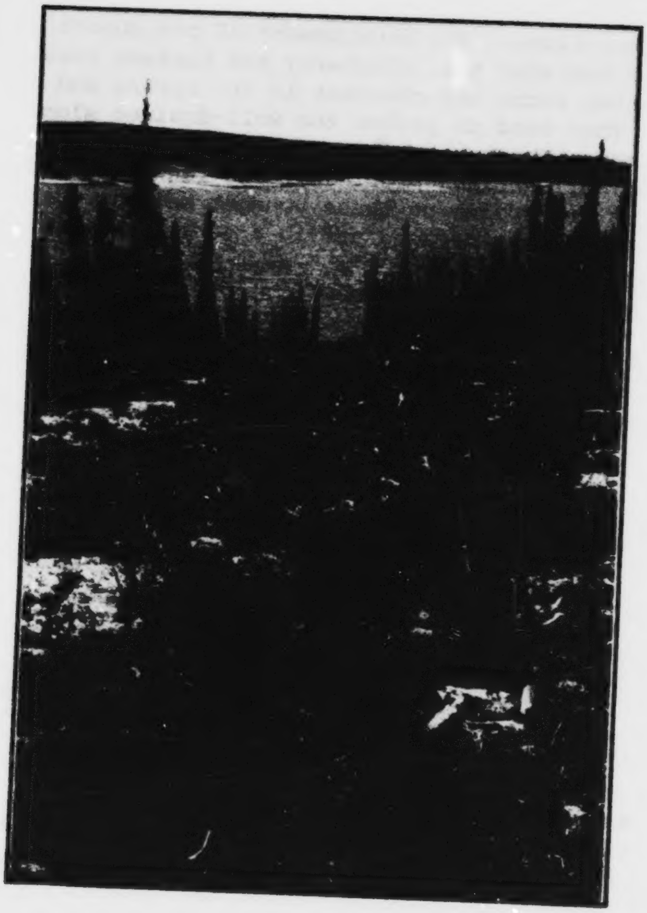

Fig. 20. Seismic line at the north end of Aubry Lake cut in March 1975. These newer lines show little evidence of thermokarst activity.

($5/10\text{-m}^2$ quadrat); the average age of the trees is 145 years. Species favouring open areas such as Labrador tea and marsh fivefinger are found here. Bitter cress (*Cardamine hyperborea*), a forb of relatively rare occurrence in the study area, grows in this area. *Sphagnum* moss is an important ground cover component.

VI. Located at the western end of the plot, area VI has an average of 7 trees/$10\text{-m}^2$ quadrat, average tree age of 86 years and average tree circumference of 16 cm. This area has a more heath-like appearance than the other areas, with *Sphagnum* hummocks covering a high percentage of the ground area. Sedges, blueberry and shrub birch are important species between the hummocks, while crowberry, lingonberry, bearberry and the willow *Salix myrtillifolia* grow on the hummocks. The horsetail *Equisetum arvense*, which has an affinity for wet habitats, and the prostrate netted willow (*Salix reticulata* ssp. *reticulata*) are found only in this area of the plot.

VII. This area in the southeastern portion of the plot supports mature white spruce. Several of the oldest tree ages recorded (360, 328, 326, 267 and 254 years) are located here. Detritus comprises a smaller percentage of the ground cover in this area than in areas with younger trees. Lichens and mosses constitute the dominant ground cover. Bearberry, lingonberry, crowberry, dryas and Labrador tea are important in the area; anemone also occurs here.

VIII. This area, situated in the southwest corner of the plot, is comprised of younger trees (average age 99 years) and of smaller average circumference (16 cm). The number of trees per $10\text{-m}^2$ quadrat averages 12. This is a moist area with lichens being the dominant ground cover. Pockets of sedges, horsetail and bearberry are common; anemone and wintergreen (*Pyrola grandiflora*) are scattered throughout the area.

## 4.3 Results of Vegetation Studies

### 4.3.1 Effects of Seismic Activity on Vegetation

The density of trees and shrubs or the number of individuals per ha is compared for seismic lines and undisturbed adjacent open spruce-lichen forest in Fig. 21. This graph shows that the undisturbed control lines have a greater shrub and tree density than do the seismic lines with the exception of seismic line 7 whose larger density can be accounted for by two reasons: an abundance of willow sprouts on the seismic line and the fact that the forest line borders a pond for a section of its length

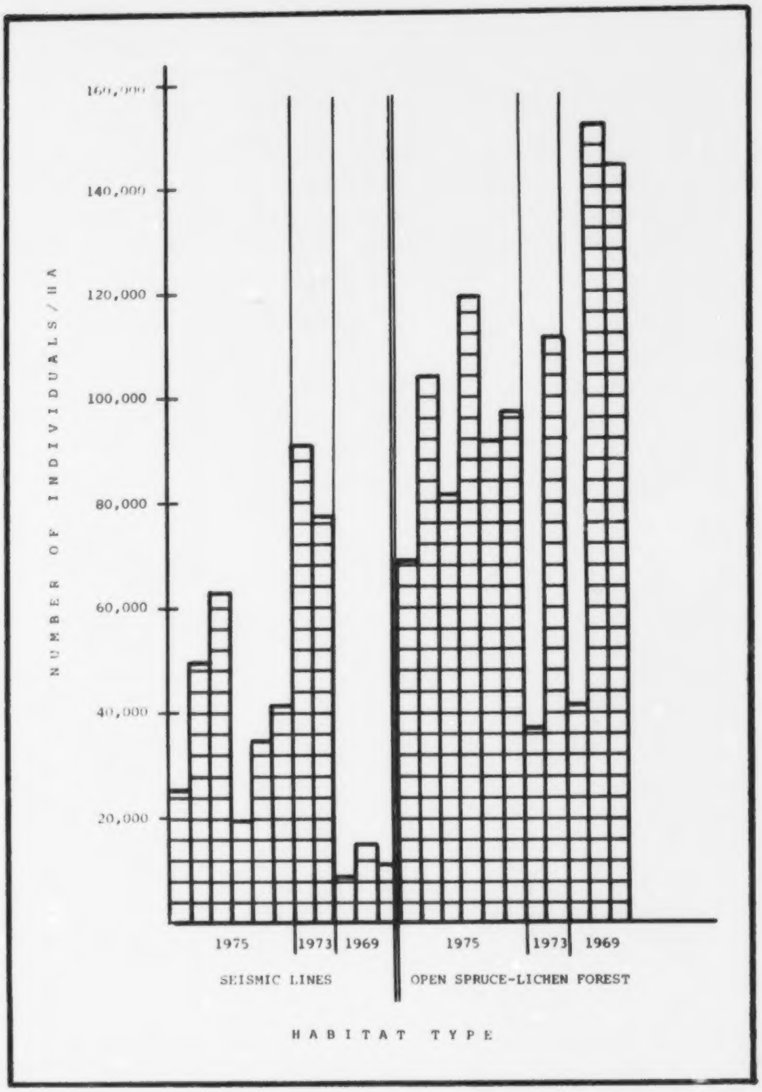

Fig. 21. Density of trees and shrubs on various-age seismic lines and in adjacent open spruce-lichen forest.

which decreases the measurement of trees and shrubs along its entire length.

Average importance values of the point-quarter sampling technique (Table 1), tabulated separately for the different years on both seismic and open spruce-lichen forest lines, show that blueberry is the most important species on the more recently cut seismic lines and also on the forest lines. Labrador tea is also an important plant species in the open spruce-lichen forest. Willows are important members of all transects, with by far the greatest regrowth on the seven year-old (1969-cut) seismic lines. Willow and blueberry both have the ability to sprout new shoots soon after cutting. White spruce is especially low in importance on older seismic lines because of the difficulty the seedlings have in becoming established on the eroded lines.

Percent cover of the different strata both on and off the seismic lines is compared between the north and south ends of Aubry Lake (Fig. 22). The tree and shrub stratum cover is from 20 to 40% greater at the south end on and off the seismic lines than at the north end. The tree and shrub stratum cover at the north end is approximately equal both on and off the seismic lines because the shrubs, which comprise the greatest cover percentage of this stratum, were not damaged by the bulldozer blades. It is also obvious from this graph that the spruce-lichen forest is more open at the sampling sites at the north end than at the south end.

The cover of grasses and sedges is 15% greater on the south-end seismic lines than on the other areas sampled. These results confirm the findings of Rickard and Slaughter (1973) who determined that cotton grass tussocks succeed on the level regions of seismic lines in Alaska and that grasses, specifically *Calamagrostis canadensis*, naturally revegetate the sloping areas of these seismic lines. The Aubry Lake south-end lines show the greatest erosion on the sloping portions because of a greater tendency for the insulative layer to be removed in the cutting of the line on slopes than on the level portions; this gives the resultant appearance of thermokarst and drainage gulleys on the south-end lines.

Lichens are abundant in the open spruce-lichen forest areas and indicate least cover on the 1969 seismic lines. Lichens are well-noted for their slow recolonization of disturbed sites.

Detritus (earth, berm, litter, rocks) obviously has much greater cover values on the seismic lines.

### 4.3.2 Species Richness On and Off Seismic Lines

The average number of species per quadrat sampled in the different habitat types ranges from 17.91 in the pond and river margins to 6.67 in

## TABLE 1

### Importance values of the tree and shrub strata on seismic lines and adjacent open spruce-lichen forest

| Line number | *Picea glauca* | *Salix* spp. | *Betula glandulosa* | *Alnus crispa* ssp. *crispa* | *Larix laricina* | *Ribes triste* | *Potentilla fruticosa* | *Shepherdia canadensis* | *Ledum palustre* ssp. *decumbens* | *Ledum palustre* ssp. *groenlandicum* | *Rhododendron lapponicum* | *Vaccinium uliginosum* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seismic Lines | | | | | | | | | | | | |
| Winter 1974-75: | | | | | | | | | | | | |
| 1A | 26.93 | 112.80 | 24.11 | 0 | 0 | 0 | 55.08 | 0 | 0 | 28.47 | 34.44 | 168.17 |
| 2A | 13.75 | 101.63 | 91.34 | 0 | 0 | 0 | 46.28 | 0 | 0 | 36.59 | 22.51 | 121.02 |
| 3A | 13.23 | 102.03 | 91.76 | 0 | 0 | 0 | 94.32 | 0 | 0 | 0 | 41.74 | 96.93 |
| 4A | 0 | 94.00 | 13.25 | 8.25 | 0 | 13.25 | 8.50 | 0 | 33.75 | 173.50 | 54.75 | 98.00 |
| 5A | 21.16 | 96.84 | 29.68 | 0 | 0 | 0 | 48.52 | 8.06 | 50.89 | 40.38 | 15.51 | 107.89 |
| 6A | 79.65 | 111.52 | 46.28 | 15.95 | 0 | 0 | 56.23 | 0 | 13.70 | 42.59 | 78.43 | 85.13 |
| **Average** | 25.79 | 103.14 | 49.40 | 4.03 | 0 | 2.21 | 51.49 | 1.39 | 16.39 | 53.59 | 41.23 | 112.86 |
| Winter 1973-74: | | | | | | | | | | | | |
| 7A | 36.51 | 50.53 | 53.75 | 13.02 | 0 | 6.91 | 0 | 0 | 78.36 | 22.04 | 41.12 | 70.13 |
| 8A | 23.23 | 86.71 | 54.06 | 26.53 | 0 | 0 | 6.92 | 0 | 16.53 | 135.95 | 6.70 | 112.90 |
| **Average** | 29.87 | 68.62 | 53.91 | 20.18 | 0 | 3.46 | 3.46 | 0 | 47.45 | 79.00 | 23.91 | 91.52 |
| Winter 1968-69: | | | | | | | | | | | | |
| 9A | 23.26 | 118.95 | 41.02 | 9.84 | 0 | 24.26 | 2.97 | 0 | 26.51 | 102.48 | 15.76 | 85.72 |
| 10A | 0 | 257.46 | 64.98 | 0 | 0 | 0 | 7.61 | 0 | 0 | 38.28 | 0 | 65.94 |
| 11A | 0 | 265.51 | 7.00 | 0 | 0 | 7.00 | 29.62 | 0 | 0 | 14.00 | 0 | 41.62 |
| **Average** | 7.75 | 213.97 | 37.67 | 3.28 | 0 | 10.42 | 22.31 | 0 | 8.84 | 51.59 | 5.25 | 64.43 |
| Forest Lines | | | | | | | | | | | | |
| Winter 1974-75: | | | | | | | | | | | | |
| 1B | 52.47 | 75.16 | 41.84 | 0 | 0 | 0 | 21.25 | 0 | 9.20 | 102.47 | 61.78 | 100.56 |
| 2B | 44.11 | 99.15 | 46.22 | 0 | 0 | 0 | 44.34 | 0 | 35.59 | 16.46 | 24.17 | 129.97 |
| 3B | 48.50 | 84.75 | 39.75 | 0 | 0 | 0 | 57.00 | 0 | 0 | 16.50 | 61.00 | 132.50 |
| 4B | 38.00 | 85.25 | 21.75 | 0 | 0 | 0 | 14.50 | 0 | 13.50 | 156.75 | 8.50 | 94.50 |
| 5B | 30.50 | 89.25 | 84.50 | 0 | 0 | 0 | 30.00 | 0 | 54.00 | 37.00 | 59.00 | 49.75 |
| 6B | 72.42 | 50.85 | 18.70 | 21.92 | 0 | 0 | 7.53 | 0 | 30.89 | 24.09 | 78.10 | 130.46 |
| **Average** | 47.67 | 80.74 | 42.13 | 3.65 | 0 | 0 | 29.10 | 0 | 23.86 | 58.88 | 48.76 | 106.29 |
| Winter 1973-74: | | | | | | | | | | | | |
| 7B | 42.83 | 102.02 | 104.53 | 7.56 | 0 | 0 | 21.79 | 0 | 63.81 | 43.54 | 48.75 | 46.75 |
| 8B | 54.55 | 31.66 | 29.02 | 0 | 0 | 0 | 0 | 0 | 63.79 | 124.51 | 30.96 | 102.40 |
| **Average** | 48.69 | 66.84 | 66.78 | 3.78 | 0 | 0 | 10.90 | 0 | 63.80 | 84.03 | 39.86 | 74.55 |
| Winter 1968-69 | | | | | | | | | | | | |
| 9B | 169.01 | 90.39 | 23.83 | 0 | 10.13 | 0 | 32.75 | 0 | 0 | 157.18 | 56.41 | 40.43 |
| 10B | 34.69 | 102.15 | 92.11 | 0 | 6.76 | 0 | 7.02 | 0 | 32.20 | 66.90 | 16.10 | 73.37 |
| 11B | 19.64 | 72.88 | 62.75 | 0 | 0 | 0 | 15.89 | 0 | 31.96 | 131.82 | 6.82 | 88.21 |
| **Average** | 74.45 | 88.47 | 59.56 | 0 | 5.63 | 0 | 18.55 | 0 | 21.39 | 118.63 | 26.44 | 67.34 |

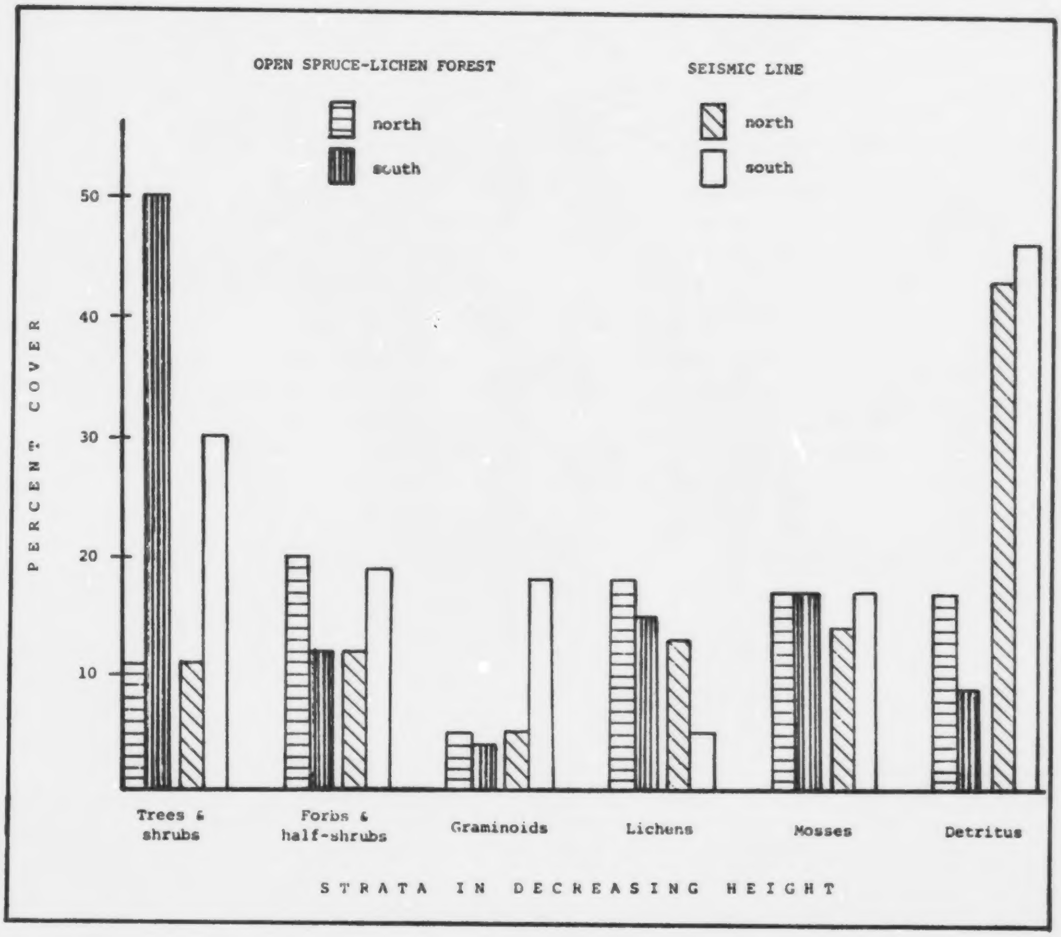

Fig. 22. Comparison of percent cover of various strata of vegetation in the open spruce-lichen forest and on seismic lines at the north and south ends of Aubry Lake.

the lichen heaths (Fig. 23). In pond and river margins, open spruce-lichen forest species are found as well as those specific to the margins and hence the greatest number of species in this habitat type. Seismic lines (17.36 species/quadrat) possess only slightly fewer species per quadrat than pond and river margins and only slightly more than open spruce-lichen forests.

### 4.3.3 Thermokarst and Erosional Subsidence along Seismic Lines

The average subsidence of the seismic lines along the six traplines (9 through 14) at the south end of Aubry Lake ranges from 26.4 to 43.5 cm and averages 34.2 cm below the adjacent undisturbed ground surface. The disturbed portion of the seismic lines, including the berms, ranges from 9.0 to 13.2 m and averages 11.1 m in width.

The traverse lines taken over the supply trails at the south end of Aubry Lake are reproduced in Fig. 24 in order to illustrate the extreme variation and extent of slumping in these track ruts; some show negligible slump while others are gullies up to 182 cm below the adjacent undisturbed ground. Average slump on the trails is 81 cm.

## 4.4 Results of Small Mammal Studies

### 4.4.1 Small Mammal Populations

The various live and kill trapping programmes conducted during the summers of 1976 and 1977 produced a total of 932 specimens. The red-backed vole is the most abundant small mammal, representing 86.8% of the total catch. The other small mammals captured are rare by comparison: meadow voles comprise only 4.8% of the total take, chestnut-cheeked voles comprise 4.2%, masked shrews 2.4% and brown lemmings 1.8%.

The relative abundance of these small mammals throughout the area would have been difficult to ascertain without trapping due to the confusing nature of the rodent sign. There were numerous areas with freshly abandoned runways and burrow systems and other areas with numerous animals which lacked obvious sign. The sites with relatively fresh and abundant sign but no animals had obviously had their local rodent populations only recently extirpated, while those sites which had animals but no abundant sign had obviously been only recently colonized.

The data from the removal trapping programme (standard traplines and exploratory traplines) point out another factor that influences the abundance of small mammals. In 20,664 TN, 833 small mammals were captured (4.03 mammals/100 TN); for the most part, these small mammals

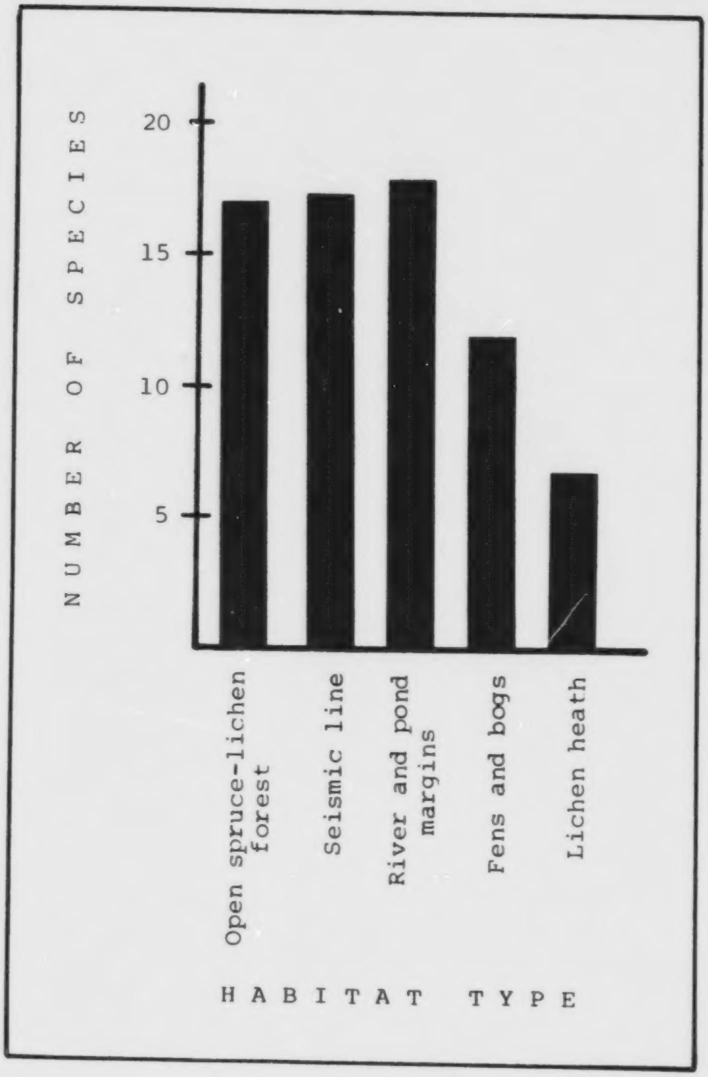

Fig. 23. Average number of plant species per quadrat in various habitats and on seismic lines.

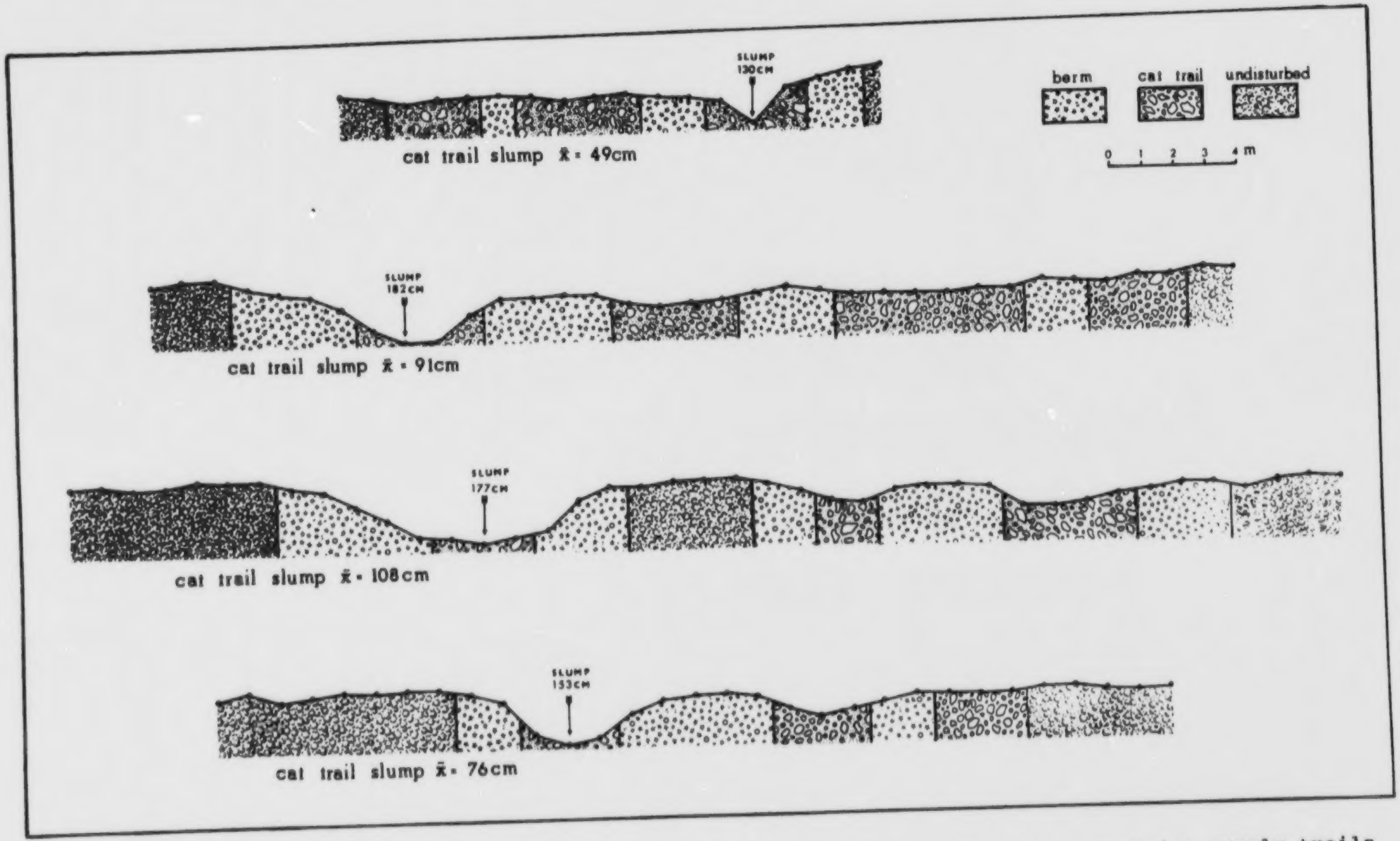
SLUMP 130CM
berm
cat trail
undisturbed
0 1 2 3 4 m
cat trail slump $\bar{x}$ = 49cm
SLUMP 182CM
cat trail slump $\bar{x}$ = 91cm
SLUMP 177CM
cat trail slump $\bar{x}$ = 108cm
SLUMP 153CM
cat trail slump $\bar{x}$ = 76cm

Fig. 24. Thermokarst subsidence measurements taken along four traverse lines crossing supply trails leading to the Mobile-Colville E-15 drill site (see Fig. 4). The vertical scale is identical to the horizontal scale. Average slump on these four trails is 81 cm below the undisturbed ground level.

were removed from localized pockets, while few were taken from vast areas of similar habitat between these pockets.

Only two localities were encountered with comparatively dense small mammal populations. One area was situated northwest of the north arm of Aubry Lake in open spruce-lichen forest and around the shorelines of two nearby thermokarst ponds. Part of this area was established as the live-trapping plot. In fact, the plot was established in this locale because it was the only site at the north end of the lake which appeared to warrant a mark-recapture study. Prior to the establishment of the plot, 40 small mammals were captured in 494 TN (8.10 mammals/100 TN) with exploratory traplines 4, 6 and 7 (Table 2). An additional 57 animals were taken in 840 TN (6.79 mammals/100 TN) on standard traplines 2B and 3B (Table 3) in the same vicinity. The trapping data in Tables 3 and 4 indicate that small mammal populations in this area increased three-fold between 1976 and 1977 (from 4.05 mammals/100 TN to 12.61 mammals/100 TN).

The only other area of relatively high small mammal density was encountered at the south end of Aubry Lake in the spruce-lichen forest surrounding standard trapline 13B. On this control line 31 small mammals were captured in 420 TN (7.38 mammals/100 TN) in 1976.

Two exploratory traplines (2 and 3) and two standard traplines (4A and 7A) did not produce any small mammals. Excluding the above-mentioned areas of relatively high density or no density, the remainder of the exploratory and standard traplines yielded from 0.24 to 9.28 mammals/100 TN.

### 4.1.2 Vole Food Preference Tests

Red-backed voles showed a marked preference toward fruit and flowers of the vascular plants offered and avoided most of the stems, leaves and roots in the cafeteria feeding trials (Table 5). The only two plants which were entirely and eagerly consumed by the red-backed voles were yellow cress (*Rorippa islandica*) and northern water carpet (*Chrysosplenium tetrandrum*); both plants occupy moist habitats (see Appendix 6.1). In fact, most of the plants bearing fruits and seeds for which the red-backed voles showed a strong preference including sedges, rushes, grasses, brambles (*Rubus* spp.), false asphodel (*Tofieldia* sp.), crowfoot (*Ranunculus confervoides*) and fleabane (*Erigeron elatus*) all thrive along the shorelines or in other moist habitats. The only plant commonly occupying the drier spruce-lichen forest which was readily eaten by the red-backed voles was alpine blueberry (*Vaccinium uliginosum*). Of the 90 species of vascular plants offered to these voles, 20 were entirely rejected.

The mushroom *Lycoperdon*, the only non-vascular plant eaten by the red-backed voles, was consumed by six of the eight test animals. Studies elsewhere in North America and Eurasia point out the use of non-vascular

### TABLE 2

Results of exploratory traplines set at the north end of Aubry Lake in 1976

| Line number and description | Date | TN | Catch* A | B | C | D | E | Mammals/100 TN |
|---|---|---|---|---|---|---|---|---|
| 1. Along shoreline of Aubry Lake in area dominated by willows and alders | 8-15 June | 336 | 1 | 0 | 0 | 0 | 0 | 0.30 |
| 2. On top of esker in old spruce-lichen burn, set among shrub birch and blueberry | 8-14 June | 394 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3. Along small creek draining into Aubry Lake, set among willows and sedges | 14-18 June | 60 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4. In *Sphagnum* bog with dense cover of shrub birch and scattered white spruce | 16-24 June | 239 | 4 | 0 | 4 | 4 | 1 | 5.43 |
| 5. In small bog | 18-21 June | 60 | 1 | 0 | 0 | 0 | 0 | 1.67 |
| 6. Along shoreline of thermokarst pond | 18-21 June | 105 | 6 | 5 | 0 | 0 | 0 | 10.48 |
| 7. Along shoreline of thermokarst pond | 18-21 June | 150 | 3 | 0 | 13 | 0 | 0 | 10.67 |
| Total |  | 1,344 | 15 | 5 | 17 | 4 | 1 | 3.13 (average) |

*Catch: A = red-backed vole, B = meadow vole, C = chestnut-cheeked vole, D = brown lemming, E = masked shrew

## TABLE 3

Summary of small mammal kill trapping on and off seismic lines at Aubry Lake in summer 1976

| | Catch* from traplines on seismic lines | | | | | Catch* from control traplines parallel to seismic lines | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | A | B | C | D | E |
| Seismic lines cut winter 1974-75 (5,040 TN) | | | | | | | | | | |
| Line 1 | 1 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 |
| Line 2 | 2 | 0 | 1** | 0 | 0 | 16 | 0 | 2 | 2 | 0 |
| Line 3 | 3 | 2** | 0 | 0 | 1** | 33 | 0 | 0 | 4 | 0 |
| Line 4 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 |
| Line 5 | 11 | 2** | 0 | 0 | 0 | 26 | 0 | 0 | 0 | 2 |
| Line 6 | 6 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| Subtotal | 23 | 4 | 1 | 0 | 1 | 92 | 0 | 2 | 6 | 2 |
| | 1.15 mammals/100 TN | | | | | 4.05 mammals/100 TN | | | | |
| Seismic lines cut winter 1973-74 (1,680 TN) | | | | | | | | | | |
| Line 7 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| Line 8 | 1 | 0 | 0 | 0 | 0 | 7 | 0 | 1 | 0 | 0 |
| Subtotal | 1 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 |
| | 0.12 mammals/100 TN | | | | | 1.19 mammals/100 TN | | | | |
| Seismic lines cut winter 1968-69 (5,040 TN) | | | | | | | | | | |
| Line 9 | 0 | 3 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 |
| Line 10 | 3 | 3 | 0 | 0 | 1 | 12 | 0 | 0 | 0 | 1 |
| Line 11 | 6 | 11 | 0 | 0 | 2 | 17 | 1 | 0 | 0 | 1 |
| Line 12 | 3 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 1 |
| Line 13 | 1 | 0 | 0 | 0 | 0 | 28 | 0 | 0 | 0 | 3 |
| Line 14 | 3 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 |
| Subtotal | 16 | 17 | 0 | 0 | 3 | 83 | 1 | 0 | 0 | 6 |
| | 1.43 mammals/100 TN | | | | | 3.57 mammals/100 TN | | | | |
| Total catch for all traplines (11,760 TN) | | | | | | | | | | |
| | 40 | 21 | 1 | 0 | 4 | 184 | 1 | 3 | 6 | 8 |
| | 1.12 mammals/100 TN | | | | | 3.44 mammals/100 TN | | | | |

*Catch: A = red-backed vole, B = meadow vole, C = chestnut-cheeked vole, D = brown lemming, E = masked shrew

**Specimens captured on seismic lines but in undisturbed bogs or pond margins

## TABLE 4

Summary of small mammal kill trapping on and off seismic lines at Aubry Lake in summer 1977

| | Catch* from traplines on seismic lines | | | | | Catch* from control traplines parallel to seismic lines | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | A | B | C | D | E |
| Seismic lines cut winter 1974-75 (5,040 TN) | | | | | | | | | | |
| Line 1 | 3 | 0 | 0 | 0 | 0 | 35 | 1 | 0 | 0 | 1 |
| Line 2 | 14 | 0 | 0 | 0 | 0 | 56 | 0 | 9 | 1 | 0 |
| Line 3 | 23 | 0 | 3 | 1 | 2 | 52 | 0 | 1 | 2 | 0 |
| Line 4 | 14 | 2 | 0 | 0 | 0 | 55 | 0 | 0 | 0 | 0 |
| Line 5 | 12 | 0 | 2 | 0 | 0 | 69 | 5 | 1 | 1 | 1 |
| Line 6 | 9 | 0 | 0 | 0 | 1 | 27 | 0 | 0 | 0 | 1 |
| Subtotal | 75 | 2 | 5 | 1 | 3 | 294 | 6 | 11 | 4 | 3 |
| | 3.41 mammals/100 TN | | | | | 12.61 mammals/100 TN | | | | |
| Seismic lines cut winter 1968-69 (2,520 TN) | | | | | | | | | | |
| Line 9 | 0 | 1 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 |
| Line 10 | 7 | 2 | 0 | 0 | 1 | 39 | 0 | 0 | 0 | 0 |
| Line 11 | 9 | 6 | 0 | 0 | 0 | 32 | 0 | 0 | 0 | 0 |
| Subtotal | 16 | 9 | 0 | 0 | 1 | 93 | 0 | 0 | 0 | 0 |
| | 2.06 mammals/100 TN | | | | | 7.38 mammals/100 TN | | | | |
| Total catch for all traplines (7,560 TN) | 91 | 11 | 5 | 1 | 4 | 387 | 6 | 11 | 4 | 3 |
| | 2.96 mammals/100 TN | | | | | 10.87 mammals/100 TN | | | | |

*Catch: A = red-backed vole, B = meadow vole, C = chestnut-cheeked vole,
D = brown lemming, E = masked shrew

## TABLE 5

Vole food preferences as determined by cafeteria feeding trials

| Plant species offered | Red-backed vole | | | | | Chestnut-cheeked vole | | | | | Meadow vole | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | L | Fr | Fl | R* | S | L | Fr | Fl | R | S | L | Fr | Fl | R |
| Fungi | | | | | | | | | | | | | | | |
| *Lycoperdon* sp. | 2$^+$ | | | | | 0 | | | | | | | | | |
| Lichens | | | | | | | | | | | | | | | |
| *Peltigera apthosa* | 0 | | | | | 0 | | | | | | | | | |
| *Cladina alpestris* | 0 | | | | | 0 | | | | | | | | | |
| Musci | | | | | | | | | | | | | | | |
| *Sphagnum* sp. | 0 | | | | | 1 | | | | | | | | | |
| *Aulacomnium* sp. | | | | | | 0 | | | | | | | | | |
| *Catoscopium nigritum* | 0 | | | | | 0 | | | | | | | | | |
| *Abietinella abietina* | | | | | | 0 | | | | | | | | | |
| Hepaticae | | | | | | | | | | | | | | | |
| *Marchantia polymorpha* | | | | | | 0 | | | | | 0 | | | | |
| Vasculares | | | | | | | | | | | | | | | |
| *Lycopodium annotium* | 0 | 0 | 0 | | | 1 | 1 | 1 | | | | | | | |
| *Equisetum variegatum* | 1 | | | | | | | | | | | | | | |
| *E. scirpoides* | 0 | | | | | 1 | | | | | | | | | |
| *E. fluviatile* | 2 | | | | | 3 | | | | | | | | | |
| *E. silvaticum* | 1 | | | | | 3 | | | | | | | | | |
| *E. arvense* | 2 | | | | | 3 | | | | | | | | | |

. . . continued

## TABLE 5 (CONTINUED)

| Plant species offered | Red-backed vole | | | | | Chestnut-cheeked vole | | | | | Meadow vole | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | L | Fr | Fl | R* | S | L | Fr | Fl | R | S | L | Fr | Fl | R |
| Vasculares (continued) | | | | | | | | | | | | | | | |
| *Picea glauca* | 0+ | 0 | | | | 0 | 0 | 0 | | | | | | | |
| *Juniperus communis* | 0 | 0 | 1 | | | 0 | 0 | 0 | | | | | | | |
| *Sparganium angustifolium* | 1 | 1 | 2 | | | 3 | 3 | 3 | | | | | | | |
| *Potamogeton praelongus* | 1 | 1 | 0 | | | 0 | 0 | 0 | | | | | | | |
| *P. perfoliatus* | 1 | 1 | 0 | | | 0 | 0 | 3 | | | | | | | |
| *P. Berchtoldi* | 1 | 1 | 2 | | | 0 | 0 | 0 | | | | | | | |
| *P. filiformis* | 0 | 0 | 2 | | | 0 | 0 | 3 | | | | | | | |
| *Arctagrostis latifolia* | | | | | | 2 | 3 | 3 | | | 1 | 3 | 3 | | |
| *Calamagrostis canadensis* | 0 | 0 | 1 | | | 3 | 3 | 3 | | | | | | | |
| *C. neglecta* | | | | | | 3 | 2 | 3 | | | 3 | 3 | 3 | | |
| *C. purpurascens* | 1 | 1 | 1 | | | 2 | 3 | 2 | | | 3 | 3 | 3 | | |
| *Poa alpigens* | 0 | 0 | 1 | | | 3 | 3 | 3 | | | | | | | |
| *P. lanata* | 1 | 0 | 3 | | | 3 | 3 | 3 | | | | | | | |
| *Arctophila fulva* | 0 | 0 | 1 | | | 3 | 3 | 3 | | | | | | | |
| *Eriophorum Scheuchzeri* | 1 | 0 | 1 | | 0 | 3 | 3 | 3 | | 3 | | | | | |
| *E. brachyantherum* | | | | | | 3 | 3 | 3 | | | | | | | |
| *Trichophorum caespitosum* | 0 | 0 | 1 | | 0 | | | | | | | | | | |
| *Eleocharis acicularis* | 2 | | 2 | | 0 | 3 | | 3 | | 0 | | | | | |
| *Carex capitata* | 1 | 1 | 2 | | | | | | | | | | | | |
| *C. aquatilis* | 1 | 1 | 2 | | | 3 | 3 | 3 | | | | | | | |
| *C. limosa* | 1 | 1 | 3 | | | 3 | 3 | 3 | | | 3 | | 3 | | |
| *C. capillaris* | 0 | 0 | 1 | | | 3 | 3 | 3 | | | | | | | |
| *C. membranacea* | 0 | 0 | 1 | | | 3 | 3 | 3 | | | | | | | |
| *Juncus arcticus* | 1 | 0 | 3 | | | 2 | | 3 | | | 3 | | 3 | | |

. . . continued

TABLE 5 (CONTINUED)

| Plant species offered | Red-backed vole |  |  |  |  | Chestnut-cheeked vole |  |  |  |  | Meadow vole |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | S | L | Fr | Fl | R* | S | L | Fr | Fl | R | S | L | Fr | Fl | R |
| Vasculares (continued) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| *Juncus castaneus* | $1^+$ | 0 | 3 |  | 0 | 3 | 3 | 3 |  | 0 |  |  |  |  |  |
| *J. alpinus* | 1 | 0 | 3 |  | 0 | 3 | 3 | 3 |  | 3 |  |  |  |  |  |
| *Tofieldia pusilla* | 0 | 0 | 3 |  | 0 | 1 | 0 | 2 |  | 0 | 3 | 0 | 3 |  |  |
| *Zygadenus elegans* | 0 | 0 | 2 |  |  | 1 | 2 | 0 |  |  |  |  |  |  |  |
| *Populus balsamifera* | 0 | 0 |  |  |  | 0 | 3 |  |  |  |  |  |  |  |  |
| *Salix reticulata* | 0 | 0 | 1 |  |  | 1 | 2 | 2 |  |  |  |  |  |  |  |
| *S. glauca* | 0 | 1 | 1 |  |  | 1 | 3 | 2 |  |  |  |  |  |  |  |
| *S. myrtillifolia* |  |  |  |  |  | 2 | 2 |  |  | 1 | 0 | 1 |  |  |  |
| *S. lanata* | 0 | 0 |  |  |  | 0 | 1 |  |  |  |  |  |  |  |  |
| *S. alaxensis* |  |  |  |  |  | 2 | 3 | 2 |  |  |  |  |  |  |  |
| *S. arbusculoides* | 0 | 1 | 0 |  |  | 1 | 2 |  |  |  |  |  |  |  |  |
| *Myrica gale* | 0 | 0 | 0 |  |  | 0 | 0 | 0 |  |  | 1 | 0 | 1 |  |  |
| *Betula glandulosa* | 0 | 0 | 0 |  |  | 0 | 0 | 0 |  |  |  |  |  |  |  |
| *Alnus crispa* | 0 | 0 | 0 |  |  | 1 | 1 | 0 |  |  |  |  |  |  |  |
| *Geocaulon lividum* | 0 | 0 | 2 |  |  | 0 | 0 | 0 |  |  |  |  |  |  |  |
| *Stellaria crassifolia* | 1 | 1 | 2 |  |  | 1 | 1 |  |  |  |  |  |  |  |  |
| *Minuartia dawsonensis* | 0 | 0 | 0 |  |  | 3 | 3 | 3 |  |  |  |  |  |  |  |
| *Nuphar variegatum* | 1 | 1 | 1 |  |  | 0 | 1 | 0 |  |  |  |  |  |  |  |
| *Anemone parviflora* | 0 | 1 |  | 2 |  | 3 | 3 |  | 2 |  |  |  |  |  |  |
| *Pulsatilla patens* | 0 | 0 |  |  |  | 3 | 3 |  |  |  |  |  |  |  |  |
| *Rununculus confervoides* | 0 | 0 | 3 | 3 |  | 0 | 0 | 0 | 0 |  |  |  |  |  |  |
| *R. reptans* | 2 |  |  | 2 |  | 3 | 3 |  | 3 |  | 3 | 3 |  | 3 |  |
| *Rorippa islandica* | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |  |  |  |  |  |
| *Chrysosplenium tetrandrum* | 2 | 2 | 2 |  |  | 3 | 3 | 3 |  |  |  |  |  |  |  |

. . . continued

TABLE 5 (CONTINUED)

| Plant species offered | Red-backed vole | | | | | Chestnut-cheeked vole | | | | | Meadow vole | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | L | Fr | Fl | R* | S | L | Fr | Fl | R | S | L | Fr | Fl | R |
| Vasculares (continued) | | | | | | | | | | | | | | | |
| *Parnassia palustris* | $0^+$ | 0 | 2 | 2 | 0 | 2 | 2 | 3 | 3 | 2 | | | | | |
| *Ribes hudsonianum* | | | | | | 1 | 0 | 2 | | | 1 | 3 | 2 | | |
| *R. triste* | 0 | 0 | 1 | | | 0 | 0 | 0 | | | | | | | |
| *Rubus chamaemorus* | 0 | 0 | 3 | | | 2 | 2 | 2 | | | 0 | 0 | 3 | | |
| *R. arcticus* | 0 | 0 | 2 | 0 | | | | | | | | | | | |
| *Potentilla palustris* | 1 | 1 | 2 | | | 2 | 2 | 2 | | | | | | | |
| *P. fruticosa* | 0 | 0 | 1 | | | 0 | 0 | 0 | | | | | | | |
| *P. norvegica* | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | | 3 | | | | | |
| *Dryas integrifolia* | 0 | 0 | 1 | | | 0 | 0 | | 3 | | 1 | 1 | | | |
| *Rosa acicularis* | 0 | 0 | 2 | | | 0 | 0 | 3 | | | | | | | |
| *Oxytropis campestris* | 1 | 2 | 3 | | | 1 | 1 | 0 | | 1 | 3 | 3 | 3 | | 2 |
| *Hedysarum alpinum* | 0 | 1 | 2 | | | 3 | 3 | 3 | | | | | | | |
| *Shepherdia canadensis* | 0 | 0 | 1 | | | 1 | 1 | 2 | | | | | | | |
| *Epilobium angustifolium* | 0 | 0 | 1 | | | 1 | 1 | | 1 | | | | | | |
| *E. latifolium* | 0 | 0 | 1 | 1 | | 1 | 1 | 0 | 0 | | 1 | 0 | 1 | 0 | |
| *E. davuricum* | 0 | 0 | 0 | | | 2 | 2 | | 2 | | 1 | 1 | | 3 | |
| *Myriophyllum spicatum* | 0 | 0 | 2 | | | 0 | 0 | 3 | | | | | | | |
| *Hippuris vulgaris* | 1 | 1 | | | | 2 | 2 | | | | | | | | |
| *Pyrola asarifolia* | 0 | 0 | 0 | | 0 | 0 | 1 | 0 | | 0 | | | | | |
| *P. grandiflora* | 0 | 0 | | | 0 | 2 | 2 | | | | | | | | |
| *P. secunda* | 0 | 0 | 0 | | 0 | 0 | 1 | 0 | | 0 | | | | | |
| *Empetrum nigrum* | 0 | 0 | 2 | | | 0 | 0 | 2 | | | | | | | |
| *Ledum palustre decumbens* | 0 | 0 | | | | 1 | 1 | | | | | | | | |
| *L. palustre groenlandicum* | 0 | 0 | 0 | | | 0 | 0 | 2 | | | | | | | |

. . . continued

TABLE 5 (CONTINUED)

| | Red-backed vole | | | | | Chestnut-cheeked vole | | | | | Meadow vole | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | L | Fr | Fl | R[*] | S | L | Fr | Fl | R | S | L | Fr | Fl | R |
| Vasculares (continued) | | | | | | | | | | | | | | | |
| *Rhododendron lapponicum* | 0[+] | 0 | | | | 0 | 0 | | | | | | | | |
| *Cassiope tetragona* | 0 | 0 | | | | 1 | 0 | 1 | | | | | | | |
| *Andromeda polifolia* | 0 | 0 | 2 | | | 2 | 3 | 3 | | | 1 | 2 | 0 | | |
| *Chamaedaphne calyculata* | 0 | 0 | 1 | | | 1 | 0 | 0 | | | | | | | |
| *Arctostaphylos uva-ursi* | 0 | 0 | 2 | | | 1 | 1 | 3 | | | 0 | 0 | 0 | | |
| *A. rubra* | 1 | 0 | 2 | | | 1 | 0 | 2 | | | | | | | |
| *Vaccinium vitis-idaea* | 0 | 0 | 1 | | | 0 | 3 | 3 | | | | | | | |
| *V. uliginosum* | 0 | 0 | 3 | | | 1 | 0 | 2 | | | | | | | |
| *Oxycoccus microcarpus* | 0 | 0 | 2 | | | 2 | 2 | 2 | | | | | | | |
| *Gentiana propinqua* | 2 | 1 | | 2 | | 2 | 2 | | 3 | | 3 | 3 | | 3 | |
| *Pedicularis labradorica* | 1 | 1 | 1 | 1 | | 3 | 3 | 3 | | | 3 | 3 | 3 | | |
| *Boschniakia rossica* | 0 | 0 | 0 | | 0 | 1 | 1 | 1 | | 1 | | | | | |
| *Utricularia vulgaris* | | | | | | 1 | 1 | | 3 | | 3 | 3 | | 3 | |
| *Erigeron elatus* | 0 | 0 | 3 | | 0 | 3 | 3 | 3 | | 3 | | | | | |
| *Artemisia Tilesii* | 0 | 0 | | 1 | | 0 | 0 | | 0 | | | | | | |
| *Petasites frigidus* | | 1 | | | | | 2 | | | | | | | | |
| *Senecio congestus* | 0 | 0 | 2 | 0 | | 3 | 3 | 3 | 3 | | | | | | |
| *S. lugens* | 1 | 1 | 2 | 1 | | 1 | 1 | 1 | 1 | | 2 | 2 | 1 | 3 | |
| *Saussurea angustifolia* | 1 | 1 | 2 | | | 3 | 3 | 3 | | | | | | | |
| Total number of species offered | 94 | 83 | 71 | 12 | 14 | 100 | 87 | 70 | 14 | 14 | 22 | 19 | 15 | 6 | 1 |

[*] Plant part code: S = stem or thalli, L = leaf, Fr = fruit, Fl = flower, R = root

[+] Preference value code: 0 = rejected by all voles, 1 = accepted very poorly by some and rejected by others, 2 = acceptance variable; some rejected while others readily consumed, 3 = eagerly consumed by most voles plants in the diets of northern microtine rodents (Banfield, 1974a; Koshkina, 1957, 1961; Llano, 1956; Nasimovich *et al.*, 1948; Riewe, 1973; Shtil'mark, 1965; Vorontsev, 1961; Youngman, 1975).

Douglass (1974) examined the food habits of *Clethrionomys rutilus* from Chick Lake, N.W.T. by analyzing the stomach contents of voles captured in May and September. He found that the spring diet of the red-backed voles consists primarily of an unidentified fungus (76.68%) and horsetail (*Equisetum*) (14.44%); the other items which occurred in the samples much less frequently include the lichens *Cladonia* and *Cetraria*, Labrador tea (*Ledum*), arthropods, mosses and *Vaccinium*. In the autumn the bulk of the stomach contents was still the unidentified fungus (79.10%). There was, however, a shift in the ranking of the other items in the voles' diets, with an increased use of willow herb (*Epilobium*), grasses, seeds, mosses and insects.

Dyke (1971) reported that red-backed voles from Heart Lake, N.W.T. consume large quantities of chlorophylous materials, lichens and over-wintered seeds in the spring and various berries in the fall. They likewise depend heavily on mushrooms but do not feed on insects.

In my feeding trials, the chestnut-cheeked voles displayed a much broader feeding spectrum than did the red-backed voles. Unlike the red-backed voles, the chestnut-cheeked voles accepted stems and leaves as readily as they accepted fruit and flowers (Table 5). A large assortment of grasses, sedges, rushes, several aquatic species including horsetail (*Equisetum fluviatile*), burreed (*Sparganium* sp.), pondweeds (*Potamogeton* spp.), water milfoil (*Myriophyllum* sp.), mare's tail (*Hippuris* sp.) and bladderwort (*Utricularia* sp.) and numerous other species which occupy moist habitats were readily consumed by the chestnut-cheeked voles. Several plants which were entirely rejected or only poorly accepted by the red-backed voles were readily consumed by the chestnut-cheeked voles; the more-notable of these species are the grasses *Poa alpigens* and *Arctophila fulva*, the sedges *Carex capillaris* and *C. membranacea*, balsam poplar (*Populus* sp.), willow (*Salix glauca*), sandwort (*Minuartia* sp.), pasqueflower (*Pulsatilla* sp.), cinquefoil (*Potentilla norvegica*), *Dryas* sp., lingonberry (*Vaccinium vitis-idaea*) and lousewort (*Pedicularis labradorica*). The chestnut-cheeked voles, in fact, rejected only 10 of the 93 vascular plants offered to them in the feeding tests. The only non-vascular plant accepted by the chestnut-cheeked voles was *Sphagnum* moss, and it was only nibbled.

Very little has previously been recorded about the food habits of the rare and elusive microtine *Microtus xanthognatus*. While trapping a colony of chestnut-cheeked voles near Old Crow in the Yukon, Youngman (1975) noted 13 plants which he assumed to be food for this vole. Seven of the species recorded by Youngman were also included in my feeding trials [*Sphagnum* sp., reed bent grass (*Calamagrostis canadensis*), cloudberry (*Rubus chamaemorus*), fireweed (*Epilobium angustifolium*), bearberry (*Arctostaphylos rubra*), lingonberry (*Vaccinium vitis-idaea*) and alpine blueberry (*V. uliginosum*)]; the remaining species were either not recorded in my study area [for example, the mushrooms *Lactarius aurantiacus*, *Russula turci* and *Hebloma sordidlilum*, high bush crarberry (*Viburnum edule*) and sweet coltsfoot (*Petasites hyperboreus*)] or not used in my feeding trials. Banfield (1974a) mentions only that chestnut-cheeked voles seem to feed a great deal on horsetails and lichens. The one stomach sample examined by Douglass (1974) contained primarily the remains of horsetails (*Equisetum*) and sedges (*Carex*).

In the Aubry Lake feeding tests, there were only four species of vascular plants which were completely rejected by both the red-backed and chestnut-cheeked voles. These include two of the dominant species in the region, white spruce (*Picea glauca*) and dwarf birch (*Betula glandulosa*), plus sweet gale (*Myrica gale*) and Lapland rosebay (*Rhododendron lapponicum*).

Unfortunately, I did not obtain comparable food preference data for meadow voles because too few species (22) were presented to only one individual. However, from the data available, it appears that the meadow voles possess even broader feeding habits than do their larger relatives, the chestnut-cheeked voles. It has been shown elsewhere that meadow voles are primarily grazers, feeding on the vegetative parts of grasses, sedges, rushes and forbs, although in the winter the bark of trees and shrubs is often consumed (Bailey, 1924; Linduska, 1942; Parker, 1941; Riewe, 1973; Thompson, 1965). Occasionally berries, nuts and seeds are also eaten (Riewe, 1973). A few studies have also noted that the genus *Microtus* has a propensity for meat (Riewe, 1973; Voge, 1950; Wellwood, 1956; Zimmerman, 1965).

It might be expected that the voles would occupy habitats with the greatest diversity of palatable plants, but this does not seem to be the situation, particularly for red-backed voles. The habitats which possess the largest number of palatable plants accepted by red-backed voles in the cafeteria feeding tests (food preference codes 2 and 3) include pond and river margins (34 species), shorelines (26 species) and disturbed sites (23 species). Red-backed voles, however, were caught far less frequently in these habitats than in the undisturbed open spruce-lichen forest which possesses only 19 palatable plant species. Thus, despite the fact that seismic lines can create habitat with a greater diversity of palatable plants for red-backed voles than do undisturbed spruce-lichen forests, the voles do not take advantage of these disturbed sites. Food availability is one of the most important factors affecting animal distribution, but in this situation where there are diverse food resources in several habitats, it is obviously not the limiting factor.

### 4.4.3 Vole Home Ranges

During the 21-day trapping period on the mark-recapture plot at the north end of Aubry Lake, 99 small mammals were captured a total of 933 times. The catch consists of 92 red-backed voles, 2 chestnut-cheeked voles, 2 masked shrews, 2 brown lemmings and 1 meadow vole. Home ranges were calculated for those small mammals which were captured at three or more trap stations not in a straight line; only some of the red-backed voles were captured a sufficient number of times to permit home range calculations. Fifty were trapped from 3 to 51 times, with an average of 16 captures/vole (Table 6). The ranges are expressed as "minimum areas" formed by a line connecting the outermost points of capture. A "minimum area" is so named because it produces an home range calculation that is 50% or less than ones calculated by other commonly employed techniques such as the "inclusive boundary strip", "exclusive boundary strip" or "Manville's method" (Crawley, 1969).

It is important to note that all methods which are used to calculate small mammal home ranges may yield unrealistic measures of the area actually utilized by a small mammal since there may be extensive areas which are never visited by the small mammal in the calculated home range (for discussions of this and other problems, see Brown, 1966; Crawley, 1969; Hayne, 1949; Kikkawa, 1964; Mohr, 1947; Riewe, 1971; Stickel, 1954). Figs. 25 and 26 depict the two largest "minimum area" home ranges found on the Aubry Lake plot and illustrate this problem. The ranges include relatively large areas where the voles were never captured and, hence, probably never utilized.

I have utilized the "minimum area" method because it has had extensive use by other investigators (such as Beer, 1961; Douglass, 1974; Hayne, 1950; Sheppe, 1966 among others) and, therefore, is useful for comparative purposes.

Another problem pertaining to the calculation of small mammal home ranges is related to the size of the trapping plot; if a plot is too small, the calculated home ranges will be smaller than the actual home ranges because animals caught near the edge over-emphasize the smaller values (Stickel, 1960; Tanaka, 1951; Tanaka and Teramura, 1953). Far too many small mammal studies can fall victim to this criticism; this study, unfortunately, is no exception. As mentioned earlier, my original plot of 2.85 ha proved to be too small and was enlarged as much as possible, given the number of traps at our disposal at the time, to 5.57 ha. Figs. 27 and 28 show the home ranges of adult male and adult female red-backed voles on the enlarged plot. Sixty percent of the adult female ranges touch the edge of the plot, and all 11 adult male ranges extend to the plot's boundary.[1] Of the 29 juvenile home ranges (not shown on the figures), 25 border on the edge of the plot. Therefore, it must be

---

[1] There is one male range of 1.90 ha shown in the centre of Fig. 27; this vole was captured 19 times between 16 and 25 July including four captures at the edge of the 2.85-ha plot. The animal died before the plot was extended, and it is not known if his actual home range lay within or surpassed the extended plot.

## TABLE 6

Minimum area home ranges of red-backed voles on the Aubry Lake plot, 15 July to 5 August 1976

| | Adult ♂ | | Adult ♀ | | Juvenile (♂ and ♀) | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of captures | Home range ($m^2$) | Number of captures | Home range ($m^2$) | Number of captures | Home range ($m^2$) | Number of captures | Home range ($m^2$) |
| | 5 | 300 | 25 | 3,100 | 6 | 16,600 | 24 | 1,800 |
| | 11 | 16,000 | 5 | 300 | 19 | 2,800 | 23 | 6,000 |
| | 6 | 500 | 18 | 1,200 | 8 | 300 | 26 | 7,800 |
| | 3 | 300 | 5 | 1,500 | 23 | 1,200 | 8 | 6,100 |
| | 4 | 400 | 16 | 2,600 | 4 | 600 | 21 | 4,400 |
| | 31 | 16,500 | 7 | 400 | 14 | 1,600 | 23 | 2,200 |
| | 19 | 19,000 | 29 | 7,200 | 6 | 100 | 35 | 10,000 |
| | 20 | 2,800 | 18 | 2,700 | 8 | 200 | 22 | 3,800 |
| | 51 | 39,700 | 22 | 2,300 | 9 | 2,100 | 23 | 2,900 |
| | 4 | 1,400 | 26 | 8,000 | 8 | 2,500 | 20 | 2,600 |
| | 35 | 4,400 | | | 3 | 300 | 20 | 1,800 |
| | | | | | 7 | 1,500 | 31 | 20,800 |
| | | | | | 3 | 700 | 15 | 4,300 |
| | | | | | 15 | 1,200 | 9 | 5,500 |
| | | | | | | | 24 | 7,400 |
| Average: | 17.2 | 9,209 | 17.1 | 2,930 | | | 15.8 | 4,107 |

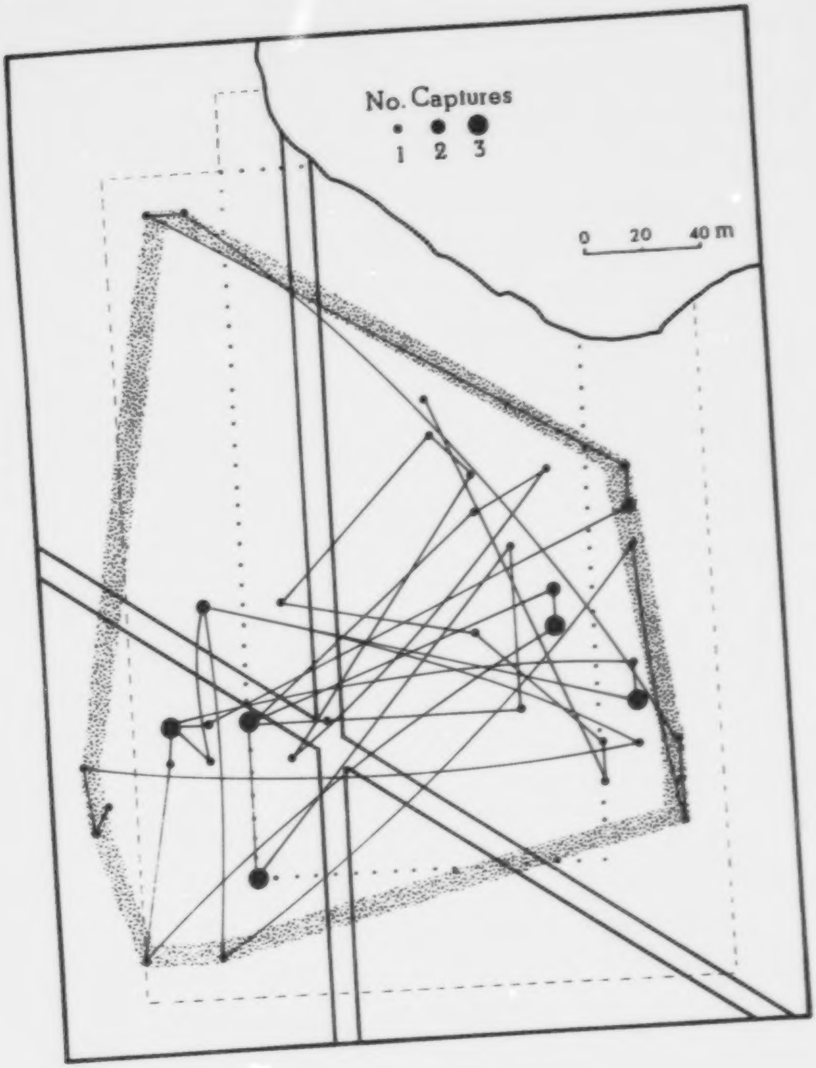

Fig. 25. The largest home range of an adult male red-backed vole on the Aubry Lake plot between 15 July and 5 August 1976. Each dot indicates a capture site; the larger the dot, the greater the number of captures. Dotted lines represent the edge of the initial 2.85-ha plot, while dashed lines indicate the final boundary of the 5.57-ha plot. Thin lines join successive capture sites. The heavy shaded line encompasses the minimum area home range of 39,700 $m^2$.

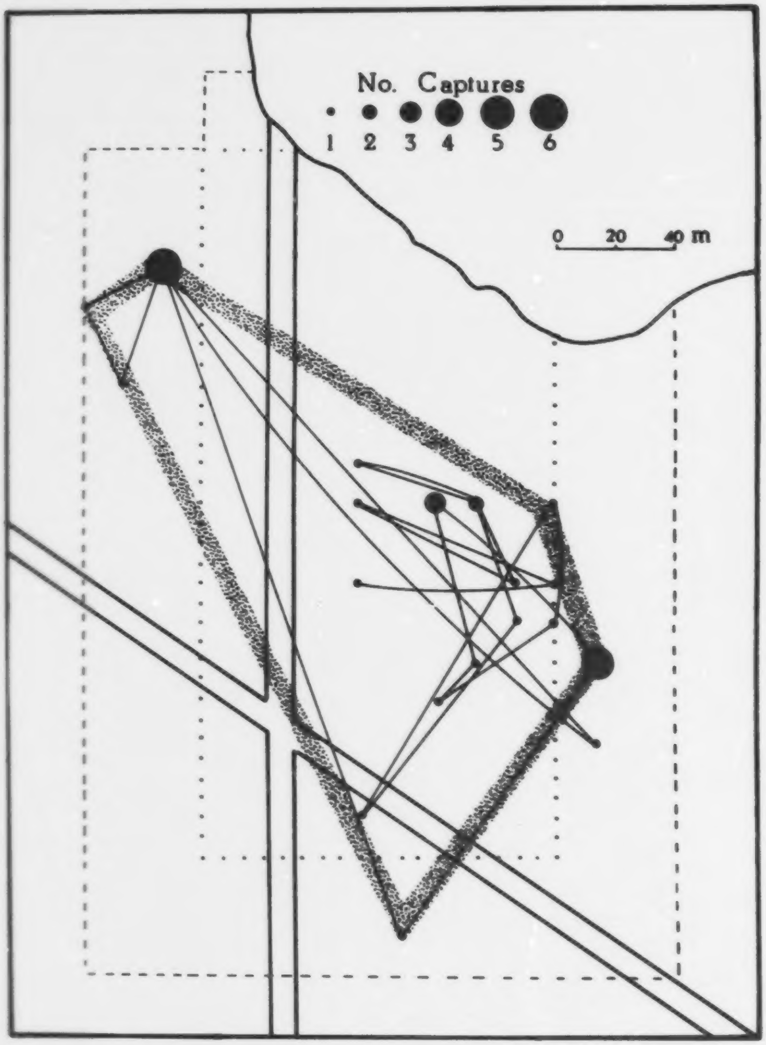
No. Captures
1
2
3
4
5
6
0
20
40 m

Fig. 26. The largest home range of a juvenile red-backed vole on the Aubry Lake plot between 15 July and 5 August 1976. Symbols as in Fig. 25. The minimum area home range is 20,800 $m^2$.

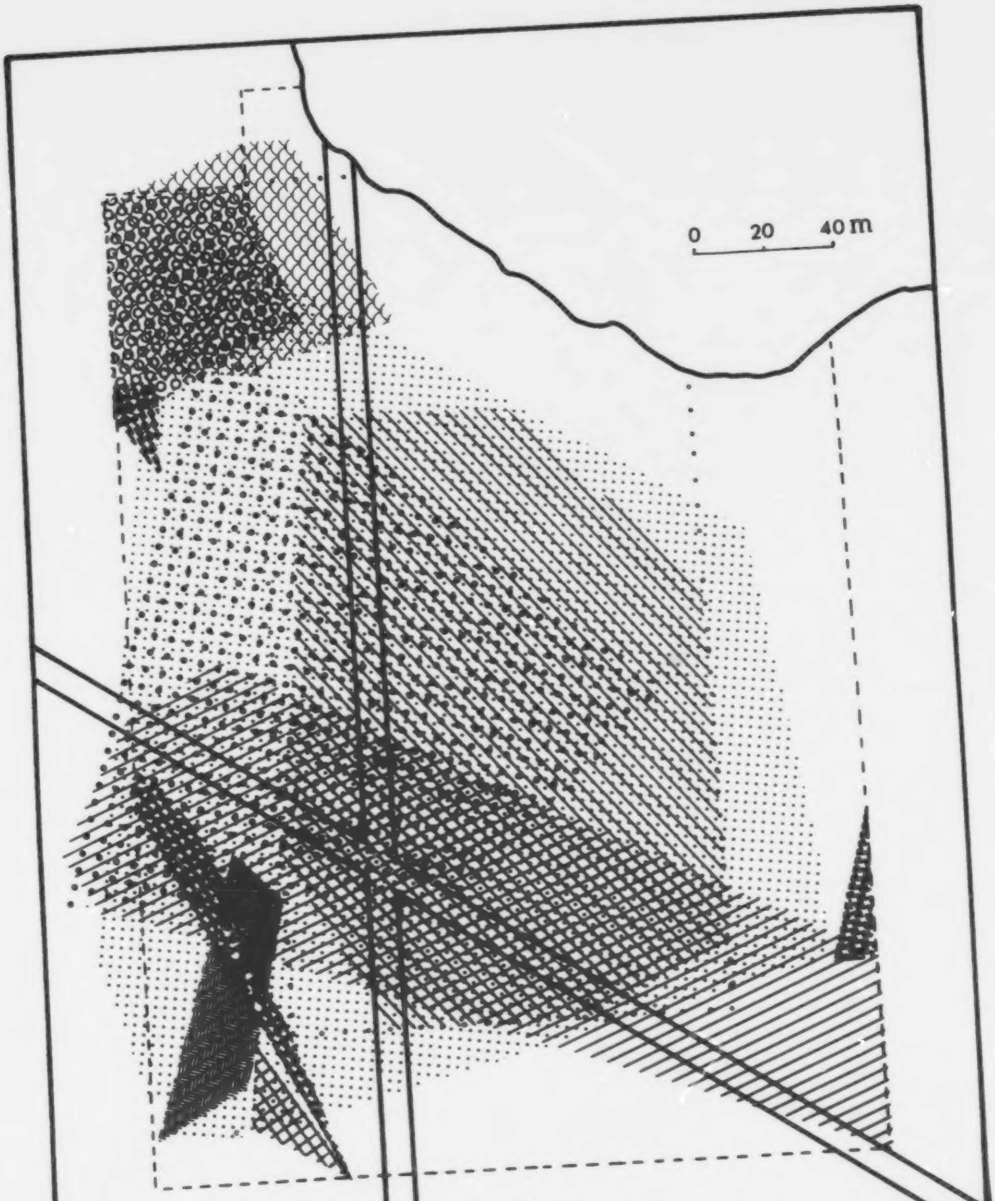

Fig. 27. Home ranges of the 11 adult male red-backed voles captured at three or more trap stations between 15 July and 5 August 1976 on the Aubry Lake plot. Dotted lines represent the edge of the initial 2.85-ha plot, while dashed lines indicate the outer boundary of the final 5.57-ha plot. The average adult male home range is 9,209 $m^2$.

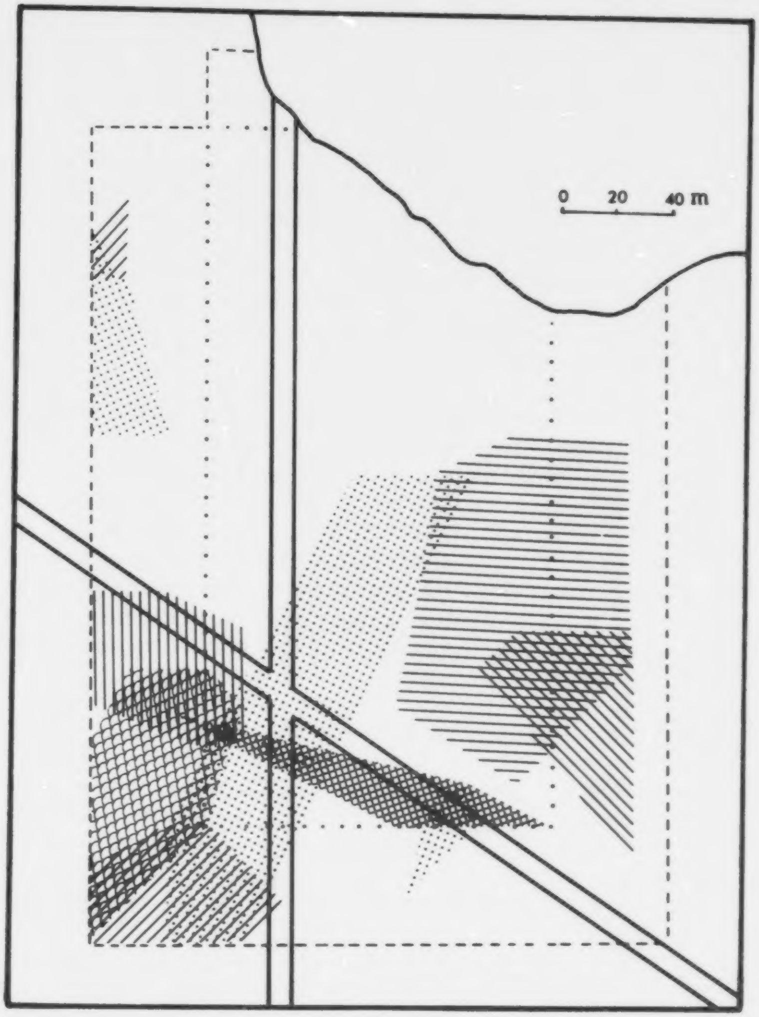

Fig. 28. Home ranges of the ten adult female red-backed voles captured at three or more trap stations between 15 July and 5 August 1976 on the Aubry Lake plot. Symbols as in Fig. 27. The average adult female home range is 2,930 $m^2$.

considered that the voles, particularly the adult males, possess larger ranges than those revealed by my trapping techniques.

Table 6 lists red-backed vole home ranges over the Aubry Lake plot from mid-July to early-August 1976. The average adult male home range of 9,209 $m^2$ (range 300 to 39,700 $m^2$) is more than three times the size of the average adult female range of 2,930 $m^2$ (range 400 to 8,000 $m^2$). This might be expected because of the females' maternal activities which keep them more closely tied to a nest site. The juvenile male and female ranges have been lumped together because of the difficulty of correctly sexing live juvenile voles. The average juvenile home range of 4,107 $m^2$ is intermediate in size between those of the adult males and adult females. The average home range for males and females, adults and juveniles combined, is 4,994 $m^2$. These relatively large home ranges are not due to the shifting of home ranges from one part of the plot to another; they are simply the result of long, rapid and frequent movements. Figs. 25 and 26 substantiate this point.

Most other studies conducted elsewhere on red-backed voles have found that this vole possesses smaller home ranges than I discovered at Aubry Lake. Douglass (1974) at Chick Lake, N.W.T. (210 km south-southwest of my study plot) employed comparable trapping methods (5-ha plots, 15.25 m x 15.25 m grid spacing, Sherman live traps set for 10 days each month from July to October and checked twice daily) and found that the average minimum area home range of *Clethrionomys rutilus* varies considerably from 233 $m^2$ for juvenile males to the largest of 3,074 $m^2$ for subadult females. He did not find any significant difference between overall male and female home ranges.

Investigations of *Clethrionomys gapperi* elsewhere in North America, often using different techniques, have discovered that this closely related species also has a variable home range size. Blair (1940a) reported the largest range of 5,018 $m^2$. Other authors reported considerably smaller ranges; for example, Marshall (cited in Gunderson, 1950) noted an average range of 2,833 $m^2$, while Gunderson (1950) and Beer (1961) discovered even smaller ranges of 931 $m^2$ and 971 $m^2$, respectively.

The home range of the bank vole, *Clethrionomys glareolus*, the European counterpart of the red-backed vole, has also been examined by several authors. Crawley (1969) noted that the bank vole possesses an average range of 753 $m^2$. Bergstedt (1966) mentioned that there was a difference between average male (2,000 $m^2$) and female (600 $m^2$) ranges; similarly, Kikkawa (1964) found an average male range of 2,208 $m^2$ and female range of 1,124 $m^2$. Brown (1954), on the other hand, found less difference in the size of the ranges of males (1,800 $m^2$) and females (1,400 $m^2$).

Obviously, the home range of a species may vary considerably in size within limits. It is generally believed that home range size is related to the size and food habits of an animal (McNab, 1963), and several studies on small rodents have shown that home range size is inversely affected by habitat quality (Beer, 1961; Layne, 1954; Riewe, 1971; Sheppe, 1966; Stickel, 1960). It has also been mentioned that age affects home range size (Burt, 1943) and that male rodents often possess larger home ranges than females, particularly during the breeding season (Bergstedt, 1966; Blair, 1940b; Getz, 1961; Howell, 1954; Van Vleck, 1969).

The larger home ranges for red-backed voles at Aubry Lake are probably related to the low biological diversity in the study area relative to other areas studied; the relatively lower biological diversity (and perhaps productivity) would force the voles to utilize larger areas in order to procure their food requirements. Even the nearby Chick Lake site has far greater diversity in terms of vegetation and physiography (Gubbe and Janz, 1974; Gubbe, 1974) which probably accounts for the smaller red-backed vole home ranges reported by Douglass (1974).

### 4.4.4 Effects of Cut Lines on Small Mammals

All small mammal captures on the Aubry Lake plot are recorded in Fig. 29. On the seismic lines crossing the plot, there were only 29 captures in 605 TN or 4.8 captures/100 TN, while off the lines in the spruce-lichen forest there were 904 captures in 2,923 TN or 30.9 captures/100 TN. Each trap off the seismic lines was visited by the small mammals 6.4 times as frequently as each trap on the lines, thus indicating a marked avoidance of the seismic lines. Even though the voles did not regularly utilize the seismic lines on the plot, the data suggest that they readily crossed the lines. At least one of the seismic lines on the plot was crossed by 23 or 46% of the red-backed vole home ranges.

The trapping data from the standard traplines used in 1976 and 1977 further substantiate the findings from the mark-recapture plot. In 19,320 TN, a total of 178 mammals or 1.84/100 TN was captured on the seismic lines, while 613 small mammals or 6.35/100 TN were captured on the undisturbed control lines.

Meadow voles were more abundant on the older seismic lines at the south end of Aubry Lake in the moist thermokarst areas than on the adjacent control lines in the spruce-lichen forest. Twenty-six meadow voles were caught in moist sites on the seismic lines, but only a single individual was taken from an undisturbed site. Twenty-eight red-backed voles were also caught in moist sites on the seismic lines, while four others were taken from drier portions of the lines. Even though the thermokarst slumps on the seismic lines provide habitat for the meadow voles, the number of *Microtus* do not compensate for the apparent decline in *Clethrionomys*; 176 red-backed voles were taken on the control lines versus 32 meadow voles on the seismic lines.

The data also indicate that the bulldozer trails which crisscross traplines 12B and 13B were even less productive in terms of small mammals

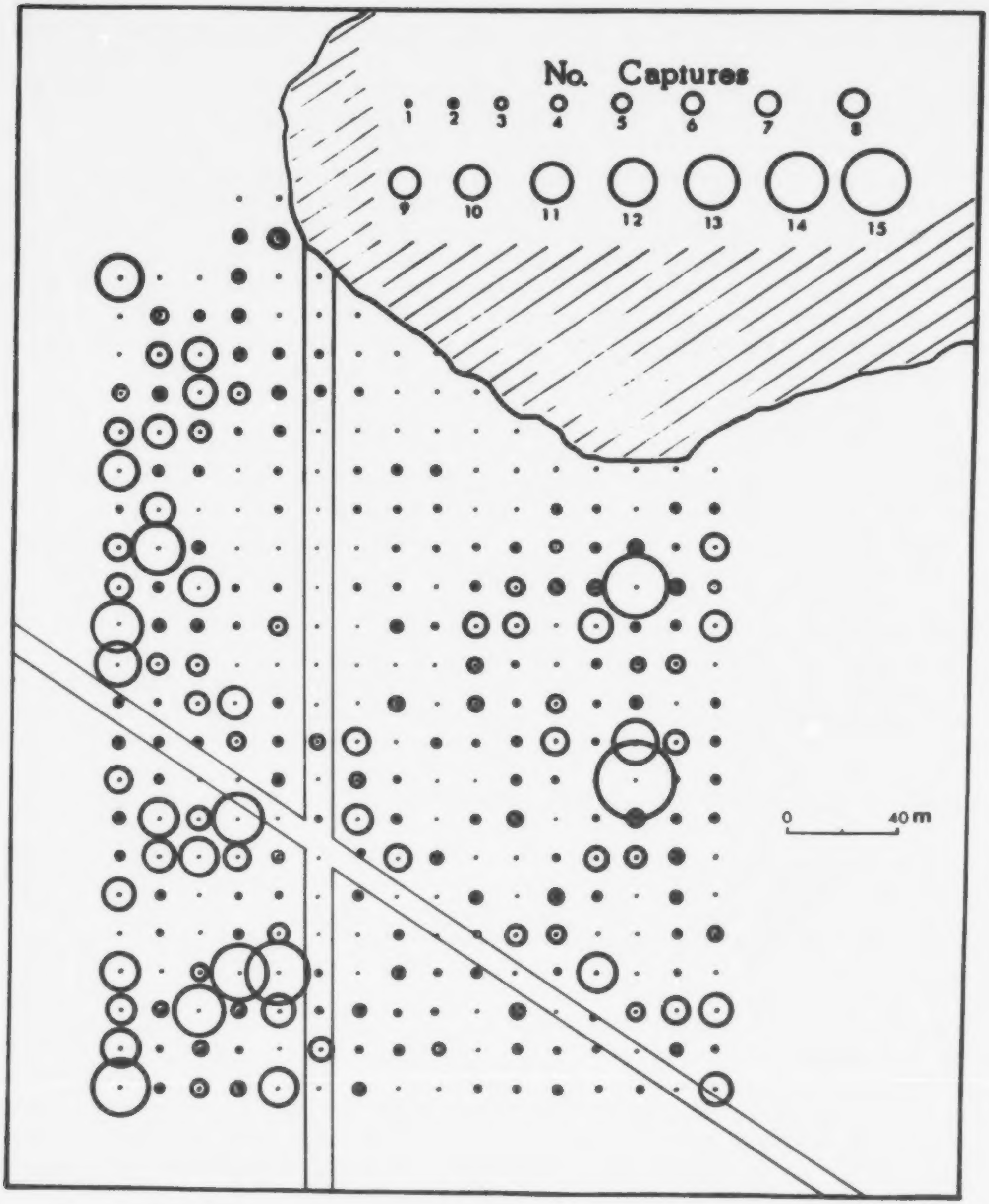
No. Captures
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
40 m

Fig. 29. Aubry Lake mark-recapture plot showing the total number of small mammal captures at each trap station. Each dot indicates a trap station; the larger the circle surrounding the station, the greater the number of captures. Each trap off the seismic lines was visited by the small mammals 6.4 times as frequently as each trap on the seismic lines.

than were the neighbouring seismic lines. On lines 12B and 13B, 29 (20.7%) of the 140 traps were set on the meandering bulldozer trails. Only 3 (8.1%) of the 37 voles were captured on these Cat trails; all the rest were caught in the undisturbed forest.

Martell (1972), working on the tundra uplands east of the Mackenzie Delta, noted that seismic lines cut or used in the summer display a change in plant communities which appears to exclude red-backed voles and collared lemmings (*Dicrostonyx torquatus*) and attract meadow voles. Seismic lines cut or used in winter, however, tend to retain the same plant associations but possess a reduced plant cover. The decrease in plant cover apparently prevents red-backed voles from spending much time on the lines, but it does not prevent them from crossing the lines.

Boles (1975) who studied several sites along the Mackenzie valley between Fort Good Hope and the Delta found the red-backed vole to be the most common mammal in the region. However, in old seismic lines with grassy vegetation, meadow voles are frequently present.

While Douglass (1974) conducted his study at Chick Lake, he had the opportunity to assess the effects of a new cut line (4 to 5 m in width) upon the small mammals. His data indicate that a narrow cut line has no immediate effect on the movements of small mammals. He mentioned, however, that a wider cut line, coupled with disturbance of ground cover, would be more likely to disrupt the movements of small mammals.

### 4.4.5 Habitat Utilization by Red-Backed Voles on the Mark-Recapture Plot

A comparison of Fig. 7 and Fig. 29 reveals that red-backed voles were not captured along the pond margin (area I). Prior to the establishment of the mark-recapture plot, an exploratory trapline (Table 2, line 7) was set along the shore of the pond, and 13 chestnut-cheeked voles and 3 red-backed voles were kill-trapped. Only one red-backed vole was captured along the portion of the pond margin included in the boundary of the plot.

Except for the lack of activity along the pond margin and a scarcity of activity on the seismic lines, red-backed voles utilized all other habitats on the plot. Two areas, the central portion of area IV and the southern portion of area VI, displayed minimal activity. No reason can be found to explain why these areas were avoided by the voles.

## 4.5 Snow Conditions during April and May 1977

Local residents said that they had experienced above average snowfall during the 1976-77 winter season. Table 7 gives a schedule of snow data collected during the spring field season (10 April to 1 May)

## TABLE 7

### Snow station data collected in the Aubry-Colville Lakes area, 10 April to 1 May 1977

| | | | Layer 1 | | | | | Layer 2 | | | | | Layer 3 | | | | | Layer 4 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Terrain | Date | Pukak temperature (°C) | Depth (cm) | Hardness (g/cm²) | Density (g/cc) | Crystal type[+] | Maximum crystal size (cm) | Depth (cm) | Hardness (g/cm²) | Density (g/cc) | Crystal type[+] | Maximum crystal size (cm) | Depth (cm) | Hardness (g/cm²) | Density (g/cc) | Crystal type[+] | Maximum crystal size (cm) | Depth (cm) | Hardness (g/cm²) | Density (g/cc) | Crystal type[+] | Maximum crystal size (cm) |
| Seismic lines | | | | | | | | | | | | | | | | | | | | | | |
| On hill | 10 April | -3.0 | 38 | 36.6 | 0.290 | P | 8 | 39 | 725.0[*] | | I | | 69 | 28.1 | 0.203 | OS | 2.5 | 84 | 8.0 | 0.130 | SS | 1 |
| On hill | 14 April | -4.0 | 51 | 439.5 | 0.335 | P | 8 | 52 | 2,666.7[*] | | I | | 73 | 85.0 | 0.280 | OS | 3.0 | 96 | 80.0 | 0.140 | OS | 1 |
| On hill | 15 April | -2.0 | 42 | 392.5 | 0.280 | P | 10 | 43 | 1,666.7[*] | | I | | 76 | 56.3 | 0.260 | OS | 3.0 | 91 | 21.7 | 0.150 | OS | 2 |
| On slope | 10 April | -4.0 | 39 | 172.9 | 0.240 | P | 7 | 40 | 70.0[*] | | I | | 65 | 71.0 | 0.215 | OS | 3.0 | 90 | 20.0 | 0.130 | SS | 2 |
| On slope | 14 April | -2.0 | 44 | 225.7 | 0.295 | P | 8 | 45 | 3,750.0[*] | | I | | 79 | 48.6 | 0.255 | OS | 3.0 | 91 | 21.7 | 0.180 | SS | 2 |
| On slope | 15 April | -1.5 | 45 | 414.3 | 0.295 | P | 12 | 46 | 1,750.0[*] | | I | | 80 | 65.0 | 0.280 | OS | 3.0 | 93 | 26.3 | 0.150 | OS | 1 |
| In valley | 10 April | -6.0 | 45 | 298.3 | 0.230 | P | 8 | 46 | 775.0[*] | | I | | 93 | 45.7 | 0.130 | OS | 1.5[-] | | | | | |
| In valley | 14 April | -4.0 | 39 | 204.3 | 0.280 | P | 6 | 40 | 2,125.0[*] | | I | | 72 | 42.5 | 0.260 | OS | 3.0 | 83 | 15.0 | 0.140 | SS | 2 |
| In valley | 15 April | -3.5 | 43 | 333.1 | 0.240 | P | 10 | 44 | 1,333.3[*] | | I | | 75 | 151.9 | 0.290 | OS | 2.0 | 86 | 20.0 | 0.125 | OS | 1 |
| Control (bush) lines | | | | | | | | | | | | | | | | | | | | | | |
| On hill | 14 April | -5.5 | 34 | 145.0 | 0.270 | P | 4 | 35 | 1,166.7[*] | | I | | 71 | 40.7 | 0.255 | OS | 2.0 | 86 | 21.7 | 0.140 | OS | 1 |
| On hill | 15 April | -2.5 | 37 | 338.1 | 0.315 | P | 6 | 38 | 1,833.3[*] | | I | | 75 | 64.4 | 0.280 | OS | 2.0 | 92 | 28.8 | 0.155 | OS | 1 |
| On slope | 10 April | -6.0 | 33 | 28.3 | 0.210 | P | 5 | 34 | 480.0[*] | | I | | 63 | 53.3 | 0.230 | OS | 2.0 | 77 | 7.3 | 0.150 | OS | 1 |
| On slope | 14 April | -6.0 | 43 | 257.5 | 0.350 | P | 5 | 44 | 1,500.0[*] | | I | | 78 | 60.0 | 0.275 | OS | 1.0 | 92 | 17.5 | 0.130 | SS | 1 |
| On slope | 15 April | -4.0 | 44 | 359.4 | 0.330 | P | 6 | 45 | 2,625.0[*] | | I | | 82 | 60.7 | 0.285 | OS | 4.0 | 93 | 21.3 | 0.140 | OS | 2 |
| In valley | 14 April | -6.0 | 38 | 155.0 | 0.270 | P | 6 | 39 | 2,166.0[*] | | I | | 82 | 60.6 | 0.195 | OS | 2.0[-] | | | | | |
| In valley | 14 April | -6.0 | 36 | 158.9 | 0.280 | P | 7 | 37 | 1,875.0[*] | | I | | 68 | 146.7 | 0.275 | OS | 2.0 | 78 | 80.0 | 0.140 | OS | 1 |
| Others | | | | | | | | | | | | | | | | | | | | | | |
| Along shoreline | 10 April | -2.0 | 41 | 244.6 | 0.245 | P | 10 | 42 | 600.0[*] | | I | | 78 | 20.0 | 0.215 | OS | 1.0 | 90 | | 0.115 | SS | 1 |
| On open lake | 14 April | -0.5 | 10 | 1,190.0 | 0.260 | P | 8 | 11 | 237.5[*] | | I | | 43 | 85.0 | 0.220 | OS | 4.0 | 54 | 16.0 | 0.160 | OS | 1 |
| Caribou cratering area | 19 April | -7.0 | 30 | 154.0 | 0.265 | P | 5 | 31 | 1,500.0[*] | | I | | 48 | 300.0 | 0.270 | OS | 2.0 | 68 | 42.5 | 0.160 | OS | 2 |
| Caribou cratering area | 1 May | -8.0 | 10 | 2,750.0 | 0.370 | P | 10 | 33 | 10,333.3 | 0.420 | OS | 2 | 55 | 125.0 | 0.325 | OS | 3.0 | 59 | 1,300.0 | 0.290 | OS | 1 |

[+] Crystal type: P = pukak, I = ice, OS = old snow, SS = settling snow

[*] Vertical hardness

[-] Layer 3 data of this station not included in mean values calculated in text

in the area of Aubry and Colville Lakes. Bush stations were generally located at right angles and 150 m from corresponding snow stations taken on seismic lines (Fig. 30). Temperatures during the sampling period averaged a daily high of -3°C and a daily low of -20°C. Thawing conditions did not seriously deteriorate the snowcover until 22 April. Prior to this, snowcover in the predominant spruce-lichen forest had a mean depth of 85.7 cm (Fig. 31). Snow station profiles typically consisted of four layers (Table 8):

(1) The bottom pukak (hoar frost crystals formed at the base of the snowcover) layer averaged a depth of 37.9 cm, hardness 206 $g/cm^2$ and density 0.289 g/cc

(2) An old melt crust averaging 1 cm thick with a vertical hardness of 1,663.8 $g/cm^2$

(3) A layer of old snow crystals 33.9 cm average thickness with a mean hardness and density of 71 $g/cm^2$ and 0.267 g/cc, respectively

(4) A top layer of settling snow or old snow averaging 12.9 cm thick with a mean hardness of 29.4 $g/cm^2$ and density of 0.143 g/cc

Qali [snow which collects in the trees (Fig. 32) and later falls onto the snow covering the ground] blobs of varying hardness and size were occasionally encountered in exposed profiles but did not figure greatly in average snow conditions due to the low density of trees.

Two representative snow stations were taken to sample a shoreline and lake ice for comparative purposes (Table 7). Shorelines were generally characterized by fairly deep snow due to drift build-up, whereas the total depth of 54 cm shown for the snow station on lake ice (Table 7) was representative of large open lake areas.

Comparisons between average snow characteristics of profiles exposed on seismic lines and in the bush cannot provide reliable conclusions due to the small sample sizes. However, comparisons between mean conditions for these profiles suggest significant differences in total depth, depth of pukak, temperature of pukak and pukak crystal size. Average total snow depth on the seismic lines for the period 10 to 15 April 1977 was 89.7 cm ($n = 9$) as compared to 85.7 cm ($n = 7$) in the bush. This difference is significant only at a 90% confidence level (student's "t" test, $p<0.1$). Significant differences appear to exist with the depth of pukak (seismic lines significantly greater, student's "t" test, $p<0.05$), temperature of pukak (seismic lines significantly greater, student's "t" test, $p<0.01$) and pukak crystal size (seismic lines significantly greater, student's "t" test, $p<0.01$). These relationships point out the possibility that differences in snowcover characteristics on and off seismic lines may have a differential effect upon the movement behaviour of some animals,

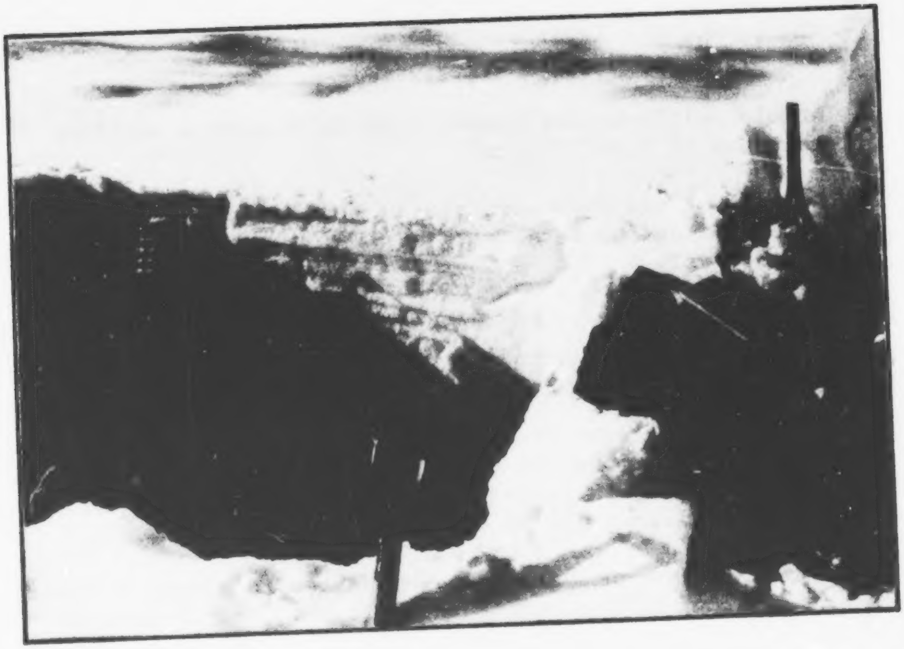

Fig. 30. Hardness measurements being taken at a snow station along a seismic line.

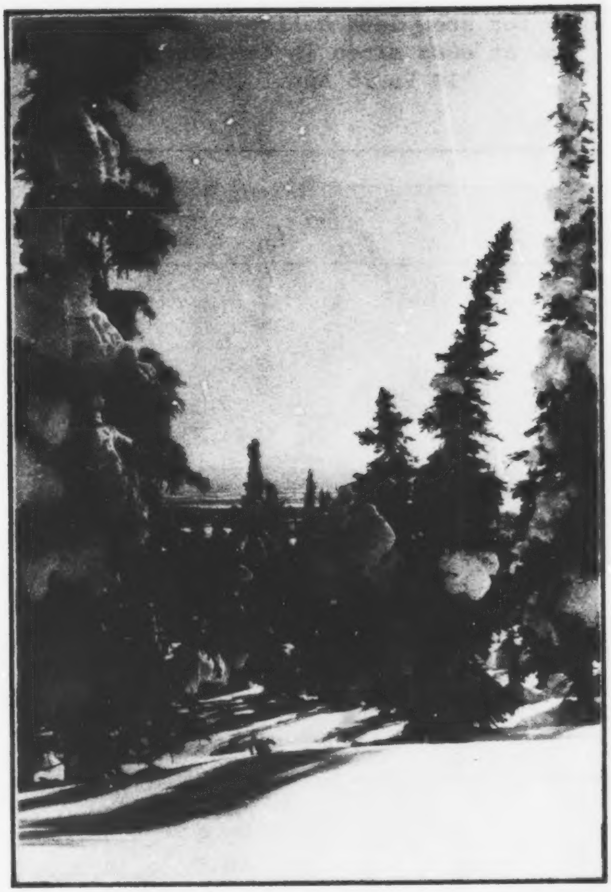

Fig. 31. Snow accumulation in the spruce-lichen forest in the Aubry-Colville area varied from 60 to 120 cm in April 1977.

## TABLE 8

Mean values for snow data collected at snow stations on seismic lines and at bush sites in the Aubry-Colville Lakes area, 10 to 15 April 1977

| | Seismic line stations (n = 9) | Control (bush) stations (n = 7) |
|---|---|---|
| $\bar{x}$ pukak temperature ($^{o}$C) | -3.33 | -5.14 |
| Layer 1 | | |
| $\bar{x}$ depth (cm) | 42.9 | 37.9 |
| $\bar{x}$ hardness (g/cm$^2$) | 279.7 | 206.0 |
| $\bar{x}$ density (g/cc) | 0.276 | 0.289 |
| $\bar{x}$ crystal type† | P | P |
| $\bar{x}$ maximum crystal size (cm) | 8.6 | 5.6 |
| Layer 2 | | |
| $\bar{x}$ depth (cm) | 43.9 | 38.9 |
| $\bar{x}$ hardness (g/cm$^2$) | 1,651.3* | 1,663.8* |
| $\bar{x}$ density (g/cc) | | |
| $\bar{x}$ crystal type† | I | I |
| $\bar{x}$ maximum crystal size (cm) | | |
| Layer 3 | | |
| $\bar{x}$ depth (cm) | 73.6 | 72.8 |
| $\bar{x}$ hardness (g/cm$^2$) | 68.6 | 71.0 |
| $\bar{x}$ density (g/cc) | 0.255 | 0.267 |
| $\bar{x}$ crystal type† | OS | OS |
| $\bar{x}$ maximum crystal size (cm) | 2.8 | 2.2 |
| Layer 4 | | |
| $\bar{x}$ depth (cm) | 89.7 | 85.7 |
| $\bar{x}$ hardness (g/cm$^2$) | 26.6 | 29.4 |
| $\bar{x}$ density (g/cc) | 0.143 | 0.143 |
| $\bar{x}$ crystal type† | SS | SS |
| $\bar{x}$ maximum crystal size (cm) | 2.0 | 1.8 |

†Crystal type: P = pukak, I = ice, OS = old snow, SS = settling snow

*Vertical hardness

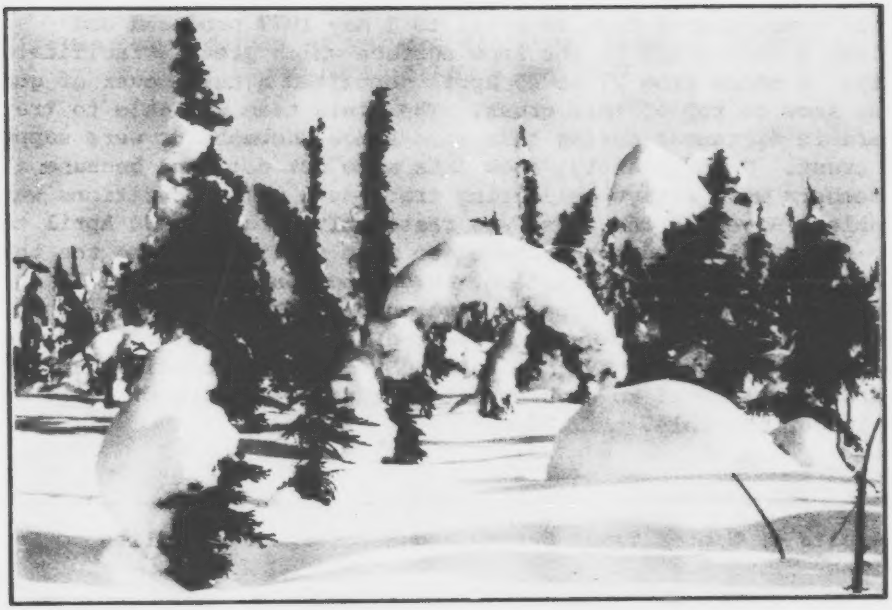

Fig. 32. Heavy qali (snow which accumulates in trees) loads on white spruce.

especially those exhibiting subnivean (below the snowcover) movement. Further investigation may be warranted here.

Subsequent to 22 April 1977, snowcover in the Aubry-Colville area deteriorated severely due to two successive thaws during which temperatures climbed as high as 19°C. A series of snow depth readings at various distances from a shoreline were taken on 1 May to show the decrease in total snow depth to that date (Table 9). Average snow depth in the bush had decreased to 69.6 cm (n = 7, 300 m from a shoreline) from the previous mean of 85.7 cm (n = 7).

Cold temperatures from 28 April to 1 May 1977 produced and maintained a melt crust on the snow surface which greatly facilitated mobility. A storm from 27 to 29 April deposited a thin cover of good tracking snow on top of this crust. The field team was able to travel considerable distances during this time since snowmobiles were supported by the crust. Unfortunately, snow data were not obtained because all field members were active collecting track data while conditions were favourable. However, the crust was reasonably hard from 30 April to 2 May. Areas which had been exposed to more sunlight during the thaw experienced harder crust formation. Crusting conditions from 30 April to 2 May were observed to support caribou but not moose. All other animals exhibiting supranivean (above the snowcover) locomotion were observed to be supported by the crust. By 3 May the condition of this crust had deteriorated to such an extent that collection of field data was no longer feasible.

## 4.6 Results of Winter Track Survey and Reactions of Wildlife to Seismic Lines

### 4.6.1 Willow Ptarmigan

Willow ptarmigan are the most noticeable and most abundant of the terrestrial wildlife in the study area. They were found wherever there were willows. Along the 20.2 km of surveyed rivers and creeks (Fig. 33) there was an average of 81.44 ptarmigan tracks/km. On lakes, which were surveyed 25 m or more from shore, ptarmigan sign was scarce, but the entire shorelines were laced with innumerable tracks among the willows.

There was far more ptarmigan sign on the control bush lines than on either the 1973-75 or 1969 seismic lines. Of the 2,606 tracks recorded along the seismic lines, all but 62 (2.4%) crossed the seismic lines at right angles, indicating very little use of the seismic lines. There were, however, numerous tracks of ptarmigan feeding in willows along the edge of the seismic lines, but these tracks were not recorded if they did not enter the open portion of the seismic line. In a few areas where willows stood above the snowcover, ptarmigan freely fed upon the willow

## TABLE 9

Mean snow depths at varying distances from the shoreline of Aubry Lake, 1 May 1977

| Distance from shoreline | No. of readings | $\bar{x}$ depth (cm) | Range (cm) |
|---|---|---|---|
| At shoreline | 7 | 65.6 | 49-75 |
| 50 to 100 m in midst of caribou craters | 13 | 65.9 | 49-75 |
| 100 m | 6 | 69.3 | 56-80 |
| 200 m | 7 | 67.4 | 59-76 |
| 300 m | 7 | 69.6 | 65-75 |

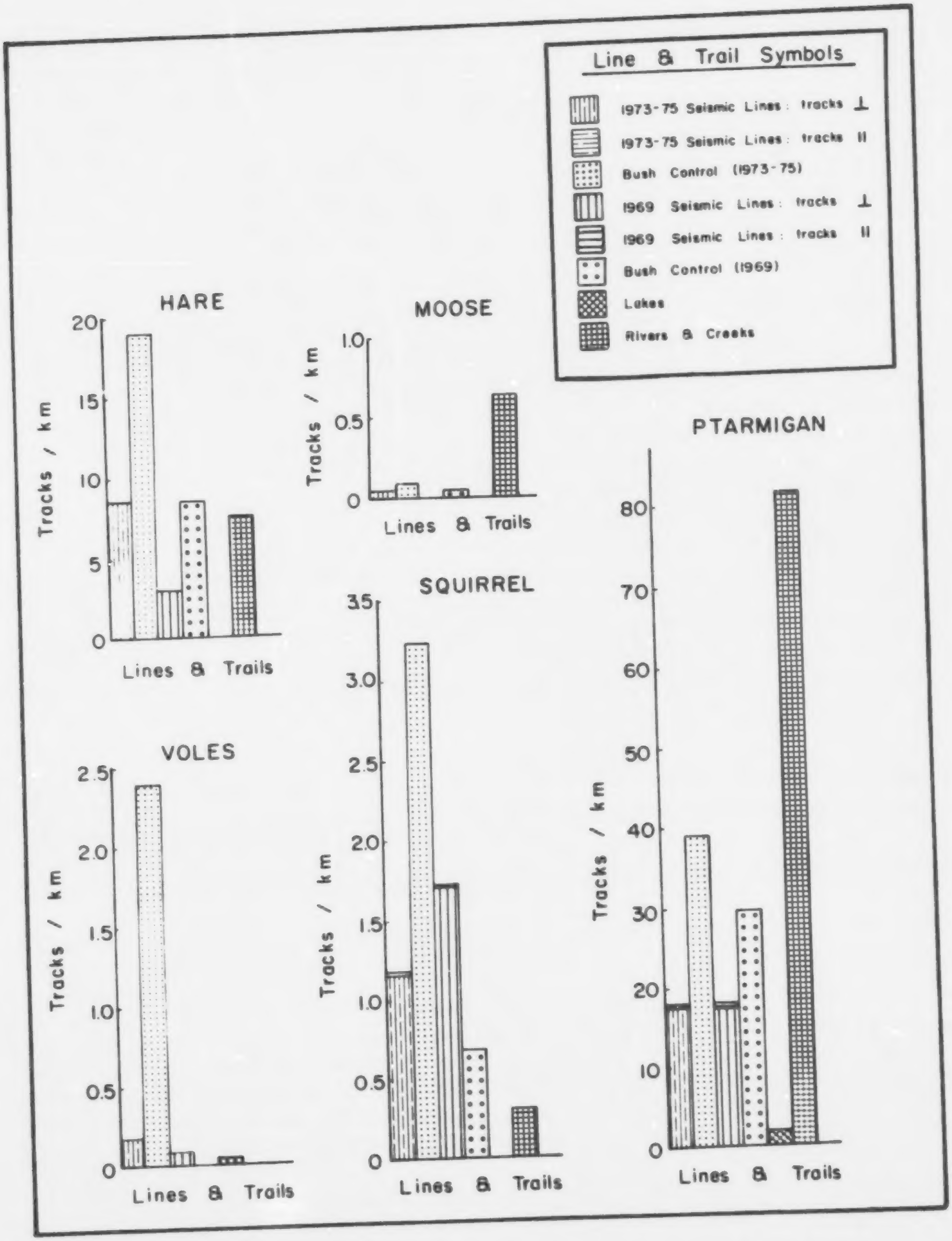

Fig. 33. Reactions of wildlife to seismic lines in the Aubry-Colville Lakes region during April and May 1977. Histograms indicate the relative activity of wildlife along seismic lines as compared to control areas in the bush or along rivers, creeks and lakes. Tracks recorded on seismic lines have been subdivided into those which followed the lines and those which merely crossed the lines at right angles.

. . . continued

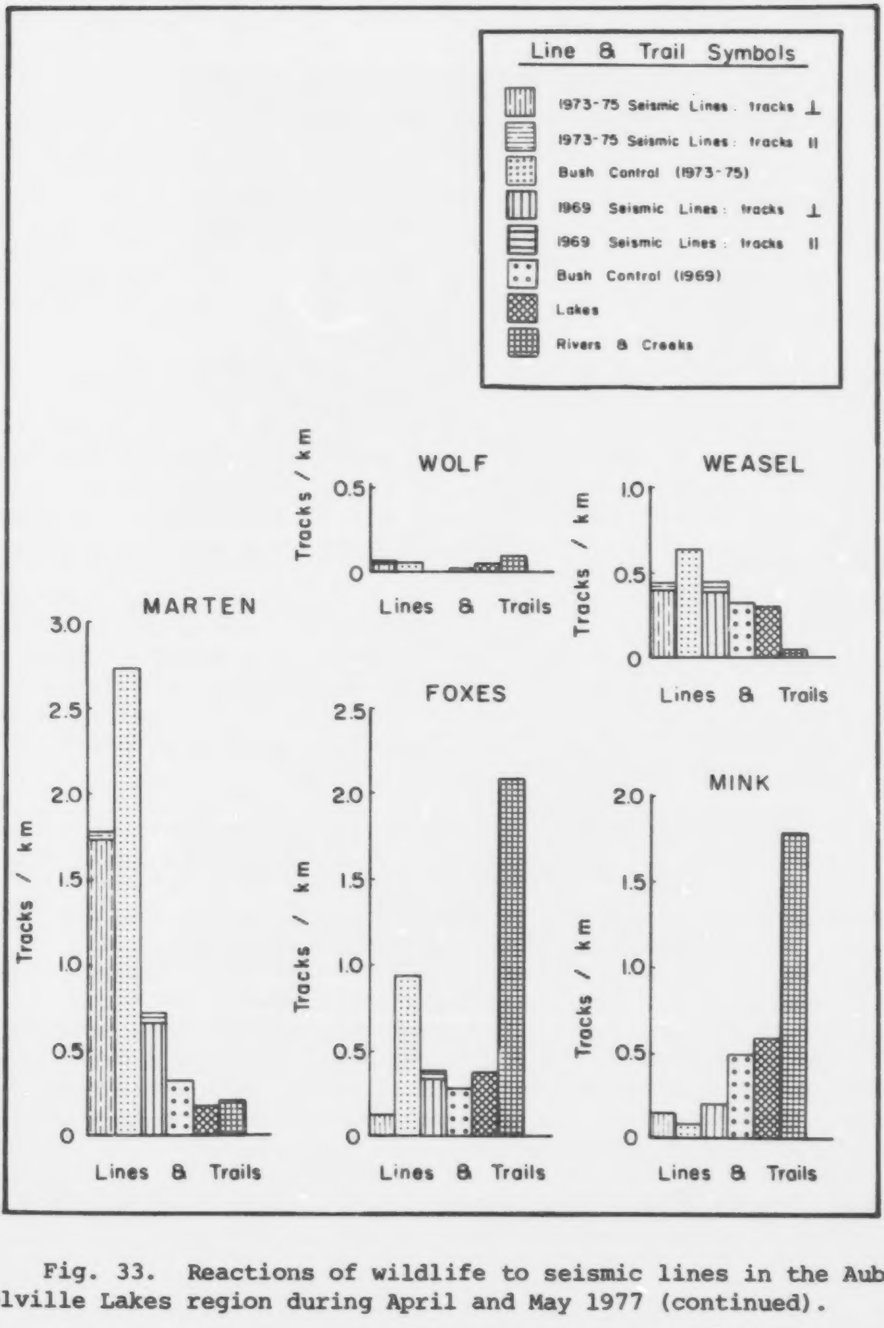

Fig. 33. Reactions of wildlife to seismic lines in the Aubry-Colville Lakes region during April and May 1977 (continued).

buds (Fig. 34). On one occasion we dug into the snow on a 1969 seismic line and uncovered willows which had previously been fed upon by ptarmigan.

Ptarmigan appear to be indifferent to seismic lines; they are neither attracted nor repelled by the lines, unless there is exposed willow and then the birds do not hesitate to feed on the line. In this regard, ptarmigan react to seismic lines as they do to exposed areas along rivers and lakes.

### 4.6.2 Voles and Lemmings

During winter voles and lemmings usually restrict their activity to the mild subnivean microenvironment; only occasionally do they make excursions into the harsh supranivean world. Therefore, only rarely are their tracks encountered on the snow surface. Under a snowcover $CO_2$ may accumulate due to bacterial decomposition. Voles rid their burrows of excessive $CO_2$ by tunnelling up to the snow surface and allowing the gas to escape into the atmosphere. Ventilation shafts appear as small burrows 2 to 3 cm in diameter on the snow surface (Fig. 35). Only rarely are there tracks on the snow leading to or from the opening of the shafts. The denser the microtine population, the greater the number of ventilation shafts. Ventilation shafts therefore can be used as a relative indicator of vole density. Unfortunately, due to their small size, ventilation shafts can easily be overlooked under poor lighting conditions. Although ventilation shafts were recorded during the spring survey, undoubtedly many were inadvertently overlooked.

Many more ventilation shafts were noted in bush at the north end of Aubry Lake than elsewhere. In this area, we encountered two small vole colonies. One colony had 19 shafts in an area 15 m in diameter. This colony was situated in a small sedge swale in the spruce forest beneath 76 cm of snow. The second colony with 70 shafts in an area 20 m in diameter was located on the shore of Aubry Lake also among sedges. These two colonies accounted for 76% of all ventilation shafts recorded. Thirteen of the 19 shafts noted on 1973 and 1969 seismic lines were lone holes; only one cluster of six shafts was found, indicating a small vole colony. This colony was located in a natural sedge swale traversing the seismic line. Therefore this colony cannot be considered to have been utilizing habitat created by thermokarst activity resultant from cutting the line. Thus only 13 ventilation shafts were noted on 145 km of seismic lines. These observations suggest that seismic lines are no more beneficial to microtines in winter than they are in summer.

### 4.6.3 Red Squirrel

Red squirrel sign was widely scattered, most commonly being noted in

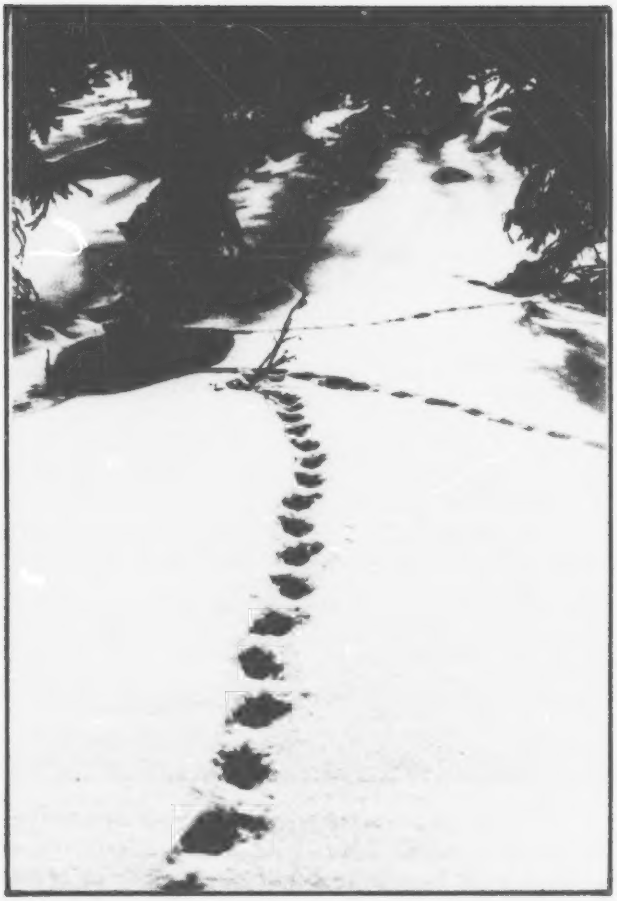

Fig. 34. Sign of ptarmigan feeding on exposed willow buds.

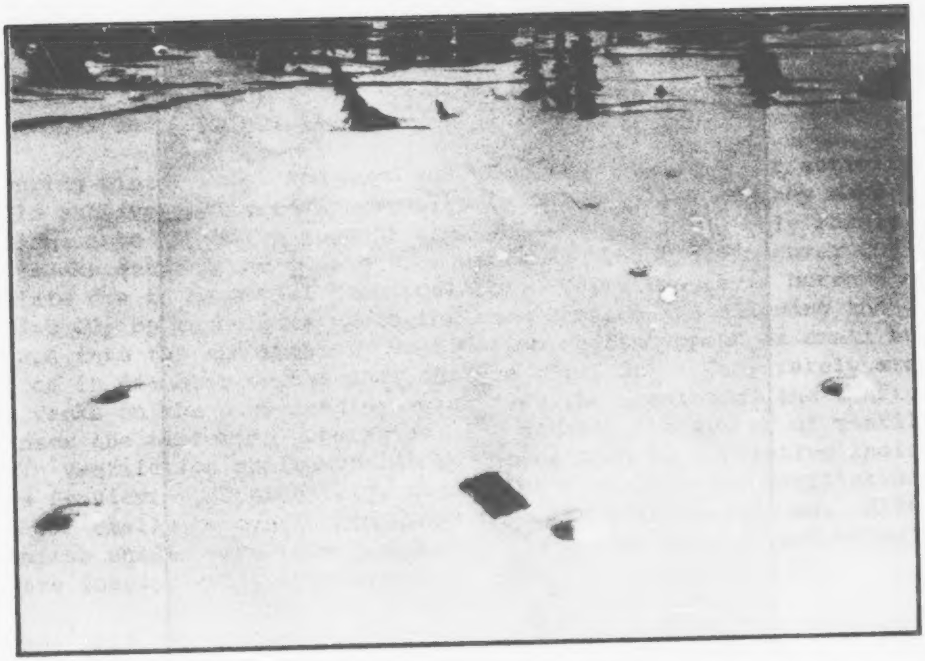

Fig. 35. Openings of ventilation shafts in a small sedge swale. These shafts identify a subnivean vole colony. Note the lack of tracks leading to or from shaft openings.

spruce forest and to a lesser extent crossing rivers and creeks. There was more than twice as much squirrel sign on the bush control trails running parallel to the 1973-75 seismic lines as on the seismic lines. On 1969 seismic lines the reverse situation was encountered: there was more than twice the sign on the lines as on the control trails. All 213 tracks recorded on the seismic lines of all ages crossed at right angles, indicating an avoidance of the open lines (Fig. 36). Two tracks entered burrows in the center of the seismic lines, which indicates possible subnivean use of the lines. Our observations suggest that squirrels do not generally utilize seismic lines.

### 4.6.4 Snowshoe Hare

Snowshoe hares were scattered in small numbers throughout the countryside but occasionally they were concentrated in small isolated pockets. It was evident that the hares were by no means at their population peak.

There were about twice as many hare tracks recorded on the bush control trails as noted on the seismic lines (Fig. 33), indicating that they tend to avoid the open lines. Of the 846 tracks recorded on the seismic lines, all but 13 crossed the lines at right angles. Of the 13 tracks which followed seismic lines, nine of them were actually following our well-packed snowmobile or snowshoe trails. Thus, snowshoe hares tend to avoid seismic lines.

### 4.6.5 Moose

Moose are uncommon in the study area, and only 23 tracks were recorded. Thirteen (56%) of these tracks were made by a single animal which was feeding and bedding along a willow-lined creek. There was no sign of moose utilizing seismic lines for either travel routes or as feeding grounds. Five moose tracks were recorded on seismic lines, but all crossed the lines at right angles (Fig. 33).

### 4.6.6 Caribou

From 19 to 30 April 1977 a total of 1,000 to 1,500 caribou were observed, usually in scattered bands of 200 to 400 along the east shore of Aubry Lake where they were making intensive use of lake ice for travelling and loafing (Fig. 37). They were not as numerous on either the southern or western portions of Aubry Lake or on the north end of Colville Lake. When we first observed them, apparent migration activity was not obvious, although caribou were constantly moving back and forth from one shoreline location to another.

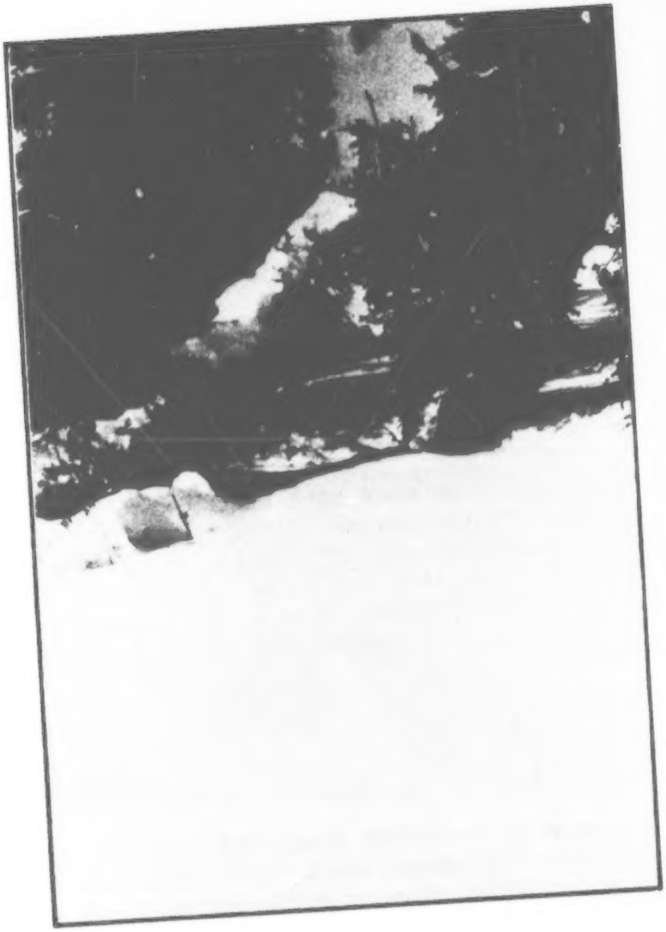

Fig. 36. Red squirrel tracks crossing a seismic line at right angles. Note the spruce tree which has been snapped off by an excessive qali load.

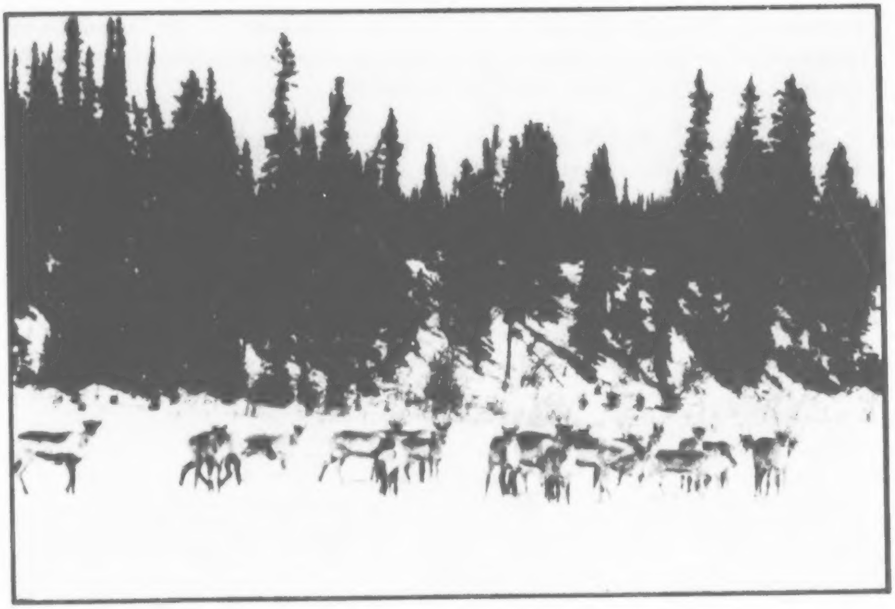

Fig. 37. Members of the Bluenose caribou herd loafing along the east shore of Aubry Lake in April 1977. The snow on the lake was relatively shallower and harder than the forest snowcover.

Caribou responded to the snow conditions during mid-April by spending most of their time on lakes and severely restricting their movement in the forest. Feeding activity was concentrated within 200 m of shorelines (Fig. 38), and caribou usually followed water routes or chains of ponds in travelling from one lake to another. It was noted on several occasions that caribou preferred to dig through previously cratered and disturbed snow rather than venture farther away from a shoreline in the deep snow of the forest. They were observed to feed mainly on ground and arboreal lichens, sedges, shrub birch and willows. Some feeding craters were occasionally observed on seismic lines, but the limited incidence of such activity is not considered to be significant. In most cases, there was a marked absence of cratering on seismic lines that traversed a feeding area near a shoreline.

There are several factors which influence an analysis of caribou activity with respect to seismic lines:

1. As mentioned, above-threshold nivean conditions tended to restrict caribou activity to areas adjacent to lakes and waterways. This factor precludes a high degree of interaction between caribou and seismic lines.

2. Field investigations were designed primarily to sample furbearer activity and were not compatible with either the observed clumped distribution of caribou activity or the gregarious behaviour of the animals.

3. The tendency of large numbers of caribou to follow line-of-file through deep snow prevented any quantitative estimates of activity since the trails would only signify the passage of two or more animals (Fig. 39). The majority of caribou activity areas observed were so intensively trampled and disturbed that quantitative descriptions could not be made.

4. Seismic lines which came out to shorelines utilized by caribou were generally oriented at approximately right angles to the shorelines. Since the majority of caribou movements were generally parallel to shorelines, the incentive to follow seismic lines was less pronounced.

Caribou activity was observed on seismic lines on only 27 occasions. Twenty of these observations occurred prior to severe deterioration of the snowcover due to spring thawing conditions (22 April). During this time, caribou trails were observed to follow seismic lines on 10 occasions for an average distance of 0.5 km. Seven of these observations took place more than 0.5 km from a shoreline, where caribou came onto a seismic line, followed it for a short distance and then left it. The remaining three observations were from seismic lines oriented at more or less right angles to a shoreline, where caribou trails followed the cleared lines down to the shore. On all occasions caribou had been

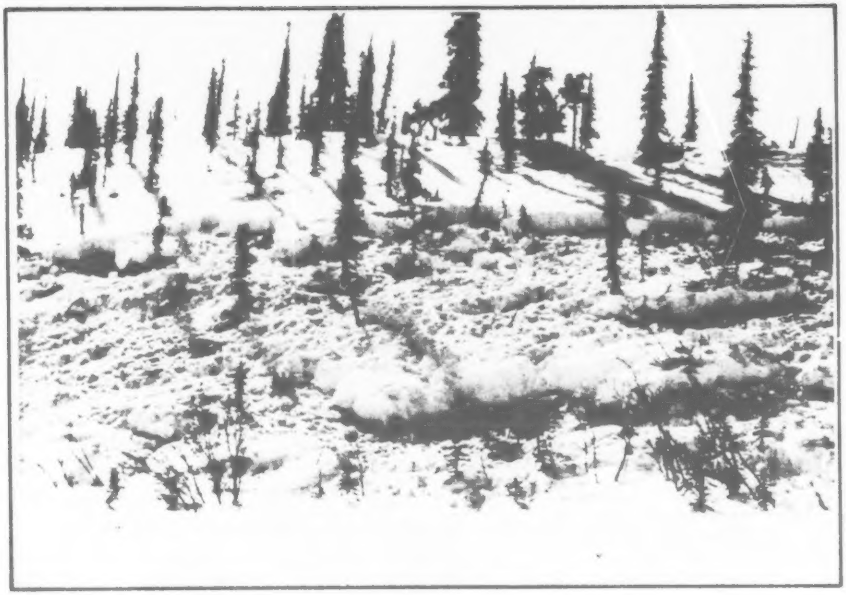

Fig. 38. Caribou feeding sign along the shoreline of Aubry Lake, April 1977. Due to the deep snowcover in the forest, the caribou usually fed within 200 m of the shoreline.